California High-Speed Train Project

Agreement No.: HSR 13-06

Standard Specifications

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Prepared for

CALIFORNIA High-Speed Rail Authority

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SECTION 02 01 00

STANDARD SPECIFICATIONS GENERAL STATEMENTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Applicability of these general statements.

B. Usage and definitions.

C. Reference standards.

D. Abbreviations.

E. On-track equipment.

1.2 APPLICABILITY OF THESE GENERAL STATEMENTS

A. These general statements are applicable to the Standard Specifications and, except as otherwise spelled out in the Construction Specifications, applicable to the Construction Specifications.

1.3 USAGE AND DEFINITIONS OF TERMS USED IN THE STANDARD SPECIFICATIONS

A. These specifications are written in imperative mood and streamlined form.

1. Imperative language is directed to the Contractor, unless specifically noted otherwise.
2. The words “shall be” are included by inference where a colon (:) is used within sentences or phrases.
3. In the interest of brevity these Specifications frequently omit modifying words such as "all" and "any" and articles such as "the" and "an," but the fact that a modifier or an article is absent from one statement and appears in another is not intended to affect the interpretation of either statement.

B. Including/Consisting of:

1. Including: Introduces a partial, representative listing of things or actions and as such means “not limited to” the partial listing.
2. Consisting of: Introduces a complete listing of things or actions which constitute the whole.

C. Acceptance or accepted: In regard to the Authority or Contracting Officer’s acceptance of a submittal or another item of work, acceptance shall be understood to mean having received a Statement of No Objection or approval.

D. Contract: As defined in the General Provisions.

E. Contract Documents: All documents made applicable to the Work by the Contract including Construction Drawings and Construction Specifications provided by the Contractor and made applicable to the Work by means of a Statement of No Objection or other acceptance.

F. Contracting Officer: Contracting Officer shall be understood to mean the Authority Representative as defined in the General Provisions.

G. Contractor's engineer, Contractor's landscape architect, and Contractor's geotechnical engineer: In addition to other qualifications specified, these individuals shall be understood to be professionals licensed in the State of California in the corresponding discipline and members of the Contractor's design team familiar with the design and engineering of the Work as well as the Construction Specifications and Construction Drawings.

H. Construction Drawings: Drawings prepared by Contractor's engineers and architects. As used within the Standard Specifications, the Construction Drawings are those drawing provided by the Contractor and made applicable to the Work by means of a Statement of No Objection or other acceptance.

I. Construction Specification: Specifications prepared by Contractor's engineers and architects. As used within the Standard Specifications, the Construction Specifications are those specifications provided by the Contractor and made applicable to the Work by means of a Statement of No Objection or other acceptance.

J. Day: As specified in the General Provisions.

K. Indicated: In reference to work to be performed by the Contractor, indicated shall be understood to mean work as required under the Contract requirements.

L. Jurisdictional Authority: As used in the Standard Specifications, jurisdictional authority shall be understood to include governments, public entities, private entities, utilities, and railroads.

M. Provide: In reference to work to be performed by the Contractor, provide shall be understood to mean "furnished and installed, complete in place".

N. Work: "Work" when capitalized means the Work as defined in the General Provisions.

O. Terms such as "construct in accordance with the approved shop drawings" or "furnish adhesive in accordance with approved submittal" shall be understood to refer to those shop drawings or other submittals which have been reviewed and have been approved by the Contractor's engineer or issued a "Statement of No Objection" from the Contracting Officer, in accordance with Contract requirements and the Contractor's Quality Management Plan, as applicable. Furthermore, "construct in accordance with the shop drawings" or "furnish adhesive in accordance with the submittal" shall be understood to mean the approved or accepted shop drawing or product submittal.

1.4 REFERENCE STANDARDS

A. The Contract Documents contain references to various standard specifications, codes, practices, and requirements for materials, equipment, work quality, installation, inspections, and tests, which references are published and issued by the organizations, societies, and associations listed herein by abbreviation and name.

B. In case of conflict between the Contract Documents and an industry standard referenced in the Contract Documents, the Contract Documents shall govern. Unless otherwise specified, references to an industry standard apply only to material, workmanship, procedures, and technical provisions. Commercial terms and legal responsibilities are not intended to be included in the reference.

C. Applicable Editions: All design requirements, material, equipment, and workmanship, specified by the number, symbol, or title of a referenced standard shall comply with the latest edition or revision thereof and all amendments and supplements thereto in effect on the date of the Request for Proposals, except where a particular edition or revision thereof is indicated in the reference. Refer to the General Provisions for applicable editions of codes.

D. The Contractor may propose to use a more recent edition or revision of a reference standard, or in the case of a particular reference standard edition being adopted by the applicable building code, an earlier edition or revision. To propose such a change, the Contractor shall submit an explanation of the differences between the two versions and the reason for the proposed change for the Contracting Officer’s acceptance or approval.

1.5 REFERENCED STANDARDS FILE

A. Referenced standards applicable to the Work through the Construction Specifications or other Contract Documents shall be obtained by the Contractor and maintained in the Contractor's office. Referenced standards shall be made readily available for use by the Contracting Officer and the Contractor’s staff including Contractor’s design team in carrying out the quality assurance and quality control programs specified in the Contract Documents, and to help ensure compliance with the requirements of the codes, specifications, test methods, practices, and other standards referenced in the Contract Documents.

1.6 ABBREVIATIONS

A. Wherever in the Contract Documents an organization’s abbreviation or acronym is used, it shall be understood to mean the full name of the respective organization.

PART 2 - PRODUCTS

2.1 CONSTRUCTION EQUIPMENT

A. On-track construction equipment proposed for use on Authority tracks shall be designed and constructed to operate within the CHSTP trainsets’ dynamic envelope specified in the CHSTP Design Criteria.

PART 3 - EXECUTION

Not used.

END OF SECTION

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SECTION 02 01 56.39

TEMPORARY TREE AND PLANT PROTECTION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Protection and maintenance of existing trees and plants.

B. Root pruning.

C. Protective fencing and signage.

D. Protective mats.

E. Invasive species removal.

F. Tree disease protection.

1.2 RELATED SECTIONS

A. Section 32 90 00, Planting.

1.3 MEETING PRIOR TO COMMENCEMENT OF WORK OF THIS SECTION

A. When specifically required under the Contract Documents or determined to be necessary by the Contractor, the Contracting Officer, the Contractor's arborist, and the Contractor's landscape architect shall meet on the site to discuss tree and plant protection and maintenance prior to clearing and grubbing operations or prior to the commencement of work of this Section, whichever is earlier. This meeting will include the field inspection of the staked limits of grading to review the existing vegetation and identify any field modifications to the work.

1.4 SUBMITTALS

A. Product Data: Submit technical data sheets for the following products including application instructions: Fertilizer, pesticide, fungicide, and herbicide.

1. Submit technical data on proposed alternative fertilizer mixtures, if applicable.

B. Samples: Ten pound sample of mulching material with source identification.

C. Tree Disease Protection Plan: If work is to be performed in the vicinity of oak trees or other plants susceptible to "Sudden Oak Death", submit a plan including procedures to be followed to protect plant life and prevent the spread of disease to or from the site.

1.5 QUALITY ASSURANCE

A. Tree and plant protection and maintenance work shall be performed under the supervision of a qualified arborist. A qualified arborist shall be either an International Society of Arboriculture (ISA) Certified Arborist or an American Society of Consulting Arborists (ASCA) Registered

Consulting Arborist and possess a minimum of five years of experience in tree and plant protection and maintenance operations.

PART 2 - PRODUCTS

2.1 WATER

A. Potable or reclaimed water approved by jurisdictional authorities and Contractor's landscape architect or arborist for landscape use.

B. Water shall be obtained from fresh water sources and shall be free from injurious chemicals and other toxic substances harmful to plant life.

C. No water which is brackish will be permitted at any time.

2.2 FERTILIZERS

A. Granular 20-20-20 commercial chemical fertilizer.

B. Granular 38-0-0 commercial chemical fertilizer.

2.3 FUNGICIDE, PESTICIDE, AND HERBICIDE

A. EPA approved materials acceptable to Contractor's landscape architect and local jurisdictional authorities.

2.4 PROTECTIVE FENCING AND SIGNAGE

A. A four foot high, orange safety delineator fence with five to six foot long posts of high carbon steel, drive type, with spade anchors.

B. Tree Protection Area signs shall be waterproof and constructed from plastic or metal stock. The words "Tree Protection Area" shall be large enough to be legible from a distance of 50 feet.

2.5 MULCHING MATERIAL

A. Mulching material shall be either wood chips or shredded bark size and type acceptable to the Contractor's landscape architect or arborist.

PART 3 - EXECUTION

3.1 GENERAL

A. The Contractor shall employ the use of a pneumatic excavating tool, as required, to determine the locations of roots in the performance of tree protection and maintenance work.

B. Stockpile no excavated material or construction materials within the drip line of any tree. Permit no parking and vehicular traffic within drip line of any tree.

C. Protect tree root systems from smothering; flooding, erosion, and excessive wetting resulting from dewatering operations; and from run-off, spillage, and drainage of solutions containing materials which would be deleterious to tree roots.

D. Prevent compaction of soil over root systems. Keep foot traffic within drip line of any tree to a minimum.

E. Where work is performed in the vicinity of oak trees or other plants susceptible to "Sudden Oak Death", implement Tree Disease Protection Plan.

3.2 ROOT PRUNING

A. Where root pruning is necessary to accommodate new construction, perform pruning in accordance with written instructions of Contractor's landscape architect or arborist (and under the observation of Contractor's arborist). Clean cut roots and minimize construction activity shock to the affected trees. Root pruning shall be performed prior to the installation of the tree protection fencing and signage.

3.3 PROTECTIVE FENCING AND SIGNAGE

A. Install protective fencing along the drip line by driving posts on five foot centers and attaching fence material.

B. In areas where construction falls within the tree protection area or within the drip line of trees to be protected, remove fencing and place protective mats and mulch as specified by the Contractor's landscape architect upon the ground surface where construction will occur. As each stage of work near trees is completed, remove protective mats and reinstall protective fencing so as to prevent soil compaction.

C. Attach the Tree Protection Area signs to the protective fencing at intervals no greater than 70 feet on center so the signs are clearly visible.

3.4 TREE MULCHING

A. Spread mulching material to a depth of three inches on the woodland side of the protective fencing for a width of fifteen feet for the entire length of fencing, unless otherwise required by the Contractor's landscape architect.

3.5 PROTECTION OF EXISTING TREES

A. Refer to the General Provisions for related requirements. Limbs which may interfere with construction operations may be removed only with written concurrence of the Contracting Officer.

B. Those existing trees which have been designated to remain, but are damaged beyond repair by construction operations, as determined by the Contractor's landscape architect or arborist and accepted by the Contracting Officer, shall be removed.

C. Replace removed trees with trees of the same genus, species, and variety, unless otherwise accepted by the Contracting Officer. The number and size of replacement trees shall be as proposed by the Contractor and accepted by the Contracting Officer to approximate the overall number and size of removed trees.

D. Those limbs and branches which have been damaged by construction operations shall be repaired. Repairing shall be accomplished by cutting damaged limbs and branches to healthy wood in accordance with "Pruning Standards for Shade Trees". Such repairs shall be carried out by experienced personnel. Sterilize pruning tools between tools' use on individual plants.

E. Bruises shall be trimmed back to sound bark and to tight cambium. If a tree limb is damaged by construction operations beyond repair, as determined by the Contractor's landscape architect or arborist, the limb shall be removed in accordance with pruning specifications in Section 31 11 00 Clearing and Grubbing.

3.6 TREE PRUNING

A. Prune existing trees where indicated on the Construction Drawings. Comply with the requirements specified in Section 31 11 00, Clearing and Grubbing. Protect existing vegetation and improvements in the vicinity of the trees.

3.7 TREE WATERING AND FERTILIZING

A. Existing trees and plants shall be watered and fertilized as required for their maintenance. Each tree shall be watered using a watering needle inserted into the ground at random points within each tree's drip line. If leaves on upper limbs become dehydrated, additional water shall be applied.

B. Where determined necessary by the Contractor's landscape architect or arborist, apply fertilizer to existing trees in accordance with Contractor's landscape architect or arborist's specifications.

C. Do not apply fertilizer until any tree pruning has been completed.

3.8 TRIMMINGS, TRASH, AND DEBRIS REMOVAL

A. Remove trash and debris from the tree and plant protection and maintenance area.

B. Dispose of trimmings, dead wood, windfalls, logs, and stumps.

C. Refer to the General Provisions for construction waste management and disposal requirements, including recycling requirements. Refer to Section 31 11 00, Clearing and Grubbing, for general debris removal and disposal requirements.

END OF SECTION

SECTION 02 21 13

SITE SURVEYS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Qualified services.

B. Surveys to establish local control.

C. Surveys for design and right-of-way engineering.

D. Surveys for verification.

E. Surveying accuracy and tolerances.

1.2 REFERENCE STANDARDS

A. The work of this Section shall be in accordance with the following standards:

B. California Department of Transportation, Caltrans “Surveys Manual”.

C. Federal Geodetic Control Committee (FGCC):

1. Geometric Geodetic Accuracy Standards and Specifications for Using GPS Relative Positioning Techniques.

1.3 SUBMITTALS

A. Refer to Section 01 33 00, Submittal Procedures, for submittal requirements. All survey reports and documents shall include a dated certification signed and sealed by a Professional Land Surveyor registered in the State of California or civil engineer as defined in Article entitled “Qualified Services and Accurate Equipment” herein, attesting to the survey's accuracy and purpose.

B. Submit a survey plan for establishing, controlling, and checking the positions for all work products and deliverables.

C. Submit a report of surveys and computations made for the purposes of densification of survey control. Include primary control monuments used, field notes made, network adjustment reports and listing of monument descriptions and positions.

D. Submit one signed copy of each survey document to the Authority for record purposes.

E. Submit mapping or Digital Terrain Model (DTM) products developed from photogrammetry or scanning technology,

F. Submit a report including methods used, survey control set or utilized, field checks made, accuracy performance achieved, etc. Include copy of mapping product(s) in electronic form as CADD files.

G. Submit survey report of all found or set monuments controlling land boundaries. Include description and location of the monument, ties made and Corner Records or Records of Survey filed.

H. Submit survey report of all field ties made for items such as existing features, locations of potholes, geotechnical borings, horizontal and vertical clearances to major structures or facilities, and catenary wire sag. Include description and location of all ties made.

1.4 QUALIFIED SERVICES AND ACCURATE EQUIPMENT

A. Land surveying services shall be performed under the direct supervision of a professional land surveyor or civil engineer currently licensed or registered in the State of California. A civil engineer providing field surveying shall have been registered prior to 1982 or have a current professional land surveyors license in the State of California. Work shall be done in conformance with the Professional Land Surveyors Act, State of California.

B. Equipment: The Contractor's instruments and other survey equipment shall be accurate, suitable for the surveys required, and in proper condition and adjustment at all times, per manufacturer's instructions.

1.5 SURVEYS TO ESTABLISH LOCAL CONTROL

A. Work shall be performed on project datums as obtained from primary control stations established and provided by the Authority. Contractor shall establish and maintain new temporary and permanent monuments and bench marks to facilitate the work of this Contract, work of adjacent and follow-on contracts, and for the Authority's on-going use. A minimum of three primary control points will be utilized in every secondary control survey. Sufficient redundant ties and closures shall be made to verify results obtained.

B. Authority's Primary Control Monuments: Preserve primary control monuments set by the Authority. If such monuments are destroyed or damaged, the Authority, through the Authority's surveyor of record, will replace them at its earliest convenience and file a Corner Record. The Contractor will be charged for the cost of replacing or restoring monuments destroyed or damaged by the Contractor's operations. This charge will be deducted from any monies due or to become due the Contractor.

   1. The Contractor shall temporarily suspend work at such points and for such reasonable times as the Authority may require for resetting survey control monuments, and the Contractor will not be entitled to any additional compensation or extension of time therefor.

C. Other Monuments and Markers: All other monuments or markers required to establish local lines and benchmarks required for the completion of the Work shall be the responsibility of the Contractor to preserve or perpetuate in accordance with Section 8771 (b) and (c) of Business and Professions Code, State of California.

1.6 SURVEYS FOR DESIGN AND RIGHT OF WAY ENGINEERING

A. Surveying Requirements: Perform surveys, reduce the field notes, and make calculations and drawings necessary to carry out the Work. Complete survey notes, drawings, and calculations as the Work progresses. Check the relative positions of all primary monuments and benchmarks to be used and report any damaged or out-of-position monuments to the Contracting Officer at once. Contractor shall check such relative positions each time the Contractor uses such monument or benchmark.

B. Datums: Perform measurements as required for the completion of the Work from survey control monuments established by the Authority. Survey maps, plats and descriptions shall make reference to the appropriate Record of Survey as filed by the Authority to document project survey control.

C. Field Notes and Records: Refer to Article entitled "Submittals" herein for submittal of field notebooks and copies of survey records.

D. Use by the Contracting Officer: The Contracting Officer may at any time use local control points and markers established by the Contractor. The Contractor's surveys are a part of the Work and may be checked by the Contracting Officer at any time. The Contractor shall be responsible for any positions, or measurements which do not comply with specified or proper tolerances, or which are otherwise defective, and for any resultant defects in the Work. The Contractor shall conduct resurveys or check surveys to correct errors indicated by review of the field notebooks or by check surveys performed by the Contracting Officer.

1. The Authority is not obligated to perform check surveys, and the absence of check surveys shall not relieve the Contractor of responsibility for the accuracy and sufficiency of all survey work.

1.7 SURVEYS FOR VERIFICATION

A. Provide surveying services as required to establish and verify local survey control, and elevations, and that the work was preformed accurately within specified surveying accuracy and tolerances as indicated in Surveying Accuracy and Tolerances herein.

B. Provide surveys to verify that mapping products used for design comply with specified tolerances and Caltrans Surveys Manual.

C. Prior to using any third party as-built drawings and data, the Contractor shall perform field surveys to verify controls and identify horizontal and vertical datum shifts to be applied.

1.8 SURVEYING ACCURACY AND TOLERANCES

A. Control Surveying Accuracy: Control traverse field surveys and computations, including surveys of control lines to determine horizontal and vertical positions of local control used for topographic and cadastral control shall meet the accuracy requirements for Second Order Surveys as specified by Caltrans Surveys Manual.

B. Tolerances: The tolerances generally applicable in the performance of design surveys shall be as set forth in this Section. Such tolerances shall not replace stricter tolerances required to carry out the Work and shall not relieve the Contractor of its responsibility for measurements as specified in this Section.

1.9 MONUMENTATION

A. The Contracting Officer will furnish the Contractor with horizontal coordinate values to minimum 1/100 of a foot and vertical values to 1/100 of a foot for all existing survey control monuments.

B. Controls for surveys other than the monumentation provided by the Authority shall not be used.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

END OF SECTION

SECTION 02 21 23

FIELD ENGINEERING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Qualified services.

B. Lines and grades.

C. Survey of layout and performance.

D. Surveys for verification.

E. Surveying accuracy and tolerances in setting survey stakes.

1.2 REFERENCE STANDARDS

A. The work of this Section shall be in accordance with the following standards:

B. California Department of Transportation, Caltrans, Surveys Manual.

C. Federal Geodetic Control Committee (FGCC):

1. Geometric Geodetic Accuracy Standards and Specifications for Using GPS Relative Positioning Techniques.

1.3 SUBMITTALS

A. Submit a plan for establishing, controlling, and checking the layout for all work. Include a plan sheet showing the horizontal distance, azimuth, and angle from the control points indicated to the references indicated.

B. Submit survey drawings showing all final centerline, station, and other Contractor-installed monumentation. Depict actual as-built conditions, including horizontal and vertical (if appropriate) location, of the constructed improvements and said improvements relationship or conformance with the Contract Documents.

C. Submit for each element of work that is constructed a survey showing actual as-built conditions indicating its conformance to the Contract Documents.

1.4 QUALIFIED SERVICES

A. Surveying services and field engineering services shall be performed under the direct supervision of a professional land surveyor or civil engineer currently licensed or registered in the State of California. A civil engineer providing field surveying shall have been registered prior to 1982 or have a current professional land surveyors license in the State of California.

1.5 LINES AND GRADES

A. Only such primary control monuments and bench marks as the Authority determines to be necessary to control establishment of the lines and grades required for completion of the Work will be set by the Authority. In general, these will consist of the primary horizontal and vertical control points indicated in the Contract Documents. Contractor shall establish work points for major structures, track alignments, and roadway alignments. Contractor shall set survey monuments at each end of station platforms to establish platform finish horizontal and vertical alignment based on the Authority control datum.

B. Authority’s Primary Control Monuments: Preserve primary control monuments set by the Authority. If such monuments are destroyed or damaged, the Authority, through the Authority’s surveyor of record, will replace them at its earliest convenience and file a Corner Record. The Contractor will be charged for the cost of replacing or restoring monuments destroyed or damaged by the Contractor's operations. This charge will be deducted from any monies due or to become due the Contractor.

1. The Contractor shall temporarily suspend work at such points and for such reasonable times as the Authority may require for resetting monuments, and the Contractor will not be entitled to any additional compensation or extension of time therefore.

C. All other stakes or markers required to establish the lines and grades required for the completion of the Work shall be the responsibility of the Contractor.

D. Establish and maintain new temporary and permanent monuments and bench marks to facilitate the work of this Contract, work of adjacent and follow-on contracts, and for the Authority’s on-going use.

1.6 SURVEYS FOR LAYOUT AND PERFORMANCE

A. Surveying Requirements: Perform all surveys for layout and performance of the Work, reduce the field notes, and make all calculations and drawings necessary to carry out such work. Complete survey notes, drawings, and calculations as the work progresses. Check the relative positions of all primary monuments and benchmarks to be used and report any damaged or out-of-position monuments to the Contracting Officer at once. The Contractor shall check such relative positions each time the Contractor uses such monument or benchmark.

B. Datum: The Contractor shall be responsible for correctly locating all lines and grades and for performing all measuring as required for the construction and completion of the Work from established reference points and information shown on the Construction Drawings.

C. Equipment: The Contractor's instruments and other survey equipment shall be accurate, suitable for the surveys required, and in proper condition and adjustment at all times, per manufacturer’s instructions.

D. Field Notes and Records: Refer to Article entitled “submittals” herein for submittal of survey records.

E. Record deviations on the Record Drawings (As-Builts) which have been accepted by the Contracting Officer.

F. Use by the Contracting Officer: The Contracting Officer may at any time use line and grade points and markers established by the Contractor. The Contractor's surveys are a part of the work and may be checked by the Contracting Officer at any time. The Contractor shall be responsible for any lines, grades, or measurements which do not comply with specified or proper tolerances, or which are otherwise defective, and for any resultant defects in the work. The Contractor shall conduct resurveys or check surveys to correct errors indicated by review of the field notebooks or by check surveys performed by the Contracting Officer.

1. The Authority is not obligated to perform check surveys, and the absence of check surveys shall not relieve the Contractor of responsibility for the accuracy and sufficiency of all survey work.

1.7 SURVEYS FOR VERIFICATION

A. Provide field engineering services as required to verify lines, levels, grades, and elevations, and that the work was constructed and installed accurately within specified tolerances.

B. Where applicable, verify constructed work including alignment and grades of structures, stations, and trackbed in preparation by previous contract or for turn-over to follow-on contracts.

C. Where applicable, provide field engineering services for obtaining field measurement of work quantities to be determined by survey.

1.8 SURVEYING ACCURACY AND TOLERANCES IN SETTING SURVEY STAKES

A. Surveying Accuracy: Control traverse field surveys and computations, including surveys of control lines to determine horizontal and vertical alignment of major structure components, and staking for construction or equipment installations shall meet the accuracy requirements for Second Order Surveys as specified by Caltrans Survey Manual.

B. Tolerances: The tolerances generally applicable in setting survey stakes shall be as set forth under this Article in the paragraph entitled "Surveying Accuracy". Such tolerances shall not replace stricter tolerances required to carry out the Work in conformance with the CHSTP Design Criteria and other Contract requirements and.

C. Project Control Surveys

1. Project Control Surveys shall be verified, densified, and maintained as necessary for the duration of the Contract. Surveys performed to verify and establish project control shall meet Second Order, Class 2, accuracy requirements for Second Order Surveys as specified by Caltrans Surveys Manual. Project Control surveys shall reliably establish the project datum locally by direct ties to a minimum of three horizontal and vertical monuments.

D. Control Surveying Accuracy: Control traverse field surveys and computations, including surveys of control lines to determine horizontal and vertical positions of local control used for topographic and cadastral control shall meet the

E. Lines and Grades

1. Perform construction staking in accordance with the specifications contained in the Caltrans Surveys Manual, Chapter 12, sections 12.3 through 12.5, regarding the staking tolerances and the placement and marking of construction stakes.

2. Construction survey accuracies shall be in accordance with the specifications of the Caltrans Surveys Manual, Chapter 5 and Figure 5-1A, therein.

1.9 MONUMENTATION

A. Use horizontal coordinate values and vertical values for all existing survey control monuments in accordance with Section 02 21 13, Site Surveys.

B. Do not use controls for surveys other than the monumentation described above unless otherwise authorized by the Contracting Officer.

1.10 FINAL ALIGNMENT AND TRACK INSPECTION

A. Survey the track to verify that the horizontal alignment, vertical alignment, and superelevation are within the tolerances specified for each type of track construction.

B. Resurvey areas which were found to exceed the tolerances after deficiencies are corrected.

C. Alignment Control Monuments: Prior to final acceptance of the trackway construction, the Contractor shall reestablish the centerline of the northbound track. Upon the acceptance of the alignment by the Contracting Officer, the Contractor shall install the permanent Alignment Control Monuments at the locations shown on the Construction Drawings for use by the Authority and follow-on contractors.

PART 2 - PRODUCTS

Not Used.

PART 3 - EXECUTION

Not Used.

END OF SECTION

SECTION 02 21 33

PHOTOGRAPHIC DOCUMENTATION

PART 1 - PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Stages of construction.

B. Disputes and claims.

C. Quality and quantity of photographs.

D. Identification of photographs.

E. Digital video recordings.

F. Aerial photography.

1.2 RELATED SECTIONS

A. Section 02 22 00, Existing Conditions Assessment.

B. Section 31 09 13, Geotechnical Instrumentation and Monitoring.

1.3 STAGES OF CONSTRUCTION PHOTOGRAPHS

A. The Contractor shall take photographs at all construction milestones and at each of the following stages of construction. Refer to Section 02 22 00, Existing Conditions Assessment for related requirements.

1. Before commencement of clearing, demolition, and subsurface work.
2. Upon completion of clearing and demolition.
3. Upon completion of subsurface work.
4. Monthly during performance of the Work, or more frequently as needed.
5. Upon completion of the Work.

B. Furnish photographs of at least three different views or vantage points taken to illustrate each milestone and stage of construction, inclusive of items on the critical path.

C. Furnish a sufficient number of photographs each month until completion of the Work to illustrate progress. Location of views shall be as agreed by the Contractor and the Contracting Officer.

D. Quality and Quantity of Photographs

1. Submit photographs as prints and in digital format uploaded to the Authority's web portal. Digital photographs shall be in pdf or jpg format.
2. Photographic prints shall be standard commercial quality, color prints, on single weight, glossy paper.
3. Size of Prints: 5 by 7 inches in size.

4. Quantity of Prints: Furnish one print of each photograph.

1.4 IDENTIFICATION OF PHOTOGRAPHS

A. Each photograph shall be identified with an unobtrusive time and date indicator and GPS coordinates (geo-tagged).

B. The following information shall be printed on the back of each print furnished and furnished for each digital photograph file:

1. Title of Contract and Contract Number.
2. Identification of subject shown.
3. Station point of camera and direction of view.

1.5 DIGITAL VIDEO RECORDINGS

A. Provide digital video recordings of all construction milestones and the following events. Refer to Section 02 22 00, Existing Conditions Assessment, for related requirements:

1. Prior to construction to document conditions within the work area and adjacent areas.
2. Start of construction, including clearing and grubbing and demolition operations, as applicable.

B. Provide digital video recordings showing pre-construction and post-construction condition of all inbound and outbound haul routes for movement of excavated materials, import of fill materials, and transport of concrete to the Jobsite, including all lanes, curbs, and gutters.

C. Upload recordings to Authority's web portal. Recordings shall be in a format and quality acceptable to the Contracting Officer. Recordings shall be uploaded no less frequently than monthly. Recordings shall include a complete, clearly spoken English narration of the events and locations being recorded. Recordings shall show an unobtrusive time and date indicator and GPS coordinates (geo-tagged). The narration of each recording shall lead off with the following identifying information:

1. Title of Contract and Contract Number.
2. Time and date recording was initiated.
3. Identification of subject shown.
4. Station point of camera and direction of view.

1.6 AERIAL PHOTOGRAPHS

A. Furnish color aerial photographs of the entire Jobsite taken prior to the start of construction, monthly after the start of construction, and at the conclusion of construction.

B. Photo Scale: Photographs shall be 9 inch x 9 inch at a maximum scale of 1 inch = 200 feet. Photographs at the conclusion of construction shall be at 1 inch = 100 feet.

C. Measurement Accuracy: Industry accepted standard.

D. Overlaps: Overlap between consecutive photographs in each flight strip will be 20 percent. The deviation range in forward overlap will not exceed plus or minus five percent. The lateral overlap shall be 20 percent. The deviation range in lateral overlap will not exceed plus or minus five percent.

E. Film Identification: Label aerial photographs with the same identifying information specified in Article entitled "Identification of Photographs" herein.

F. Quality and Quantity of Photographs:

1. Digital photographs shall be in jpg format.
2. Photographic prints shall be standard commercial quality, color prints, on glossy paper.
3. Quantity of Prints: Furnish two print of each photograph.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

Not used.

END OF SECTION

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SECTION 02 22 00

EXISTING CONDITIONS ASSESSMENT

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Preconstruction inspection.

1.2 COORDINATION

A. Coordinate the requirements of Section 31 09 13, Geotechnical Instrumentation and Monitoring, which requires early monitoring to detect possible movement of structures and other features in periods prior to construction. Document placement of monitoring devices and existing conditions at the time of placement of devices in a Preconstruction Condition Survey Report as specified herein.

1.3 SUBMITTALS

A. Submit copies of the Preconstruction Condition Survey Report. Depending on the staging of the Work, submit separate Preconstruction Condition Survey Reports for specific areas, as applicable.

B. Transmittal of the Preconstruction Condition Survey Report shall be signed by the Contractor's design team's geotechnical engineer.

1.4 AUTHORITY PARTICIPATION IN PRECONSTRUCTION INSPECTION

A. Make arrangements for access of building or facility through the Contracting Officer or directly with owner of building or facility, as applicable.

B. Notify the Contracting Officer prior to performing preconstruction inspection of buildings and structures. Make arrangements with the Contracting Officer and make such inspection at times convenient to the Contracting Officer.

C. Contracting Officer will participate in the conditional inspection of buildings or structures in the vicinity of the Work, which may possibly be affected by the Work. These surveys shall be conducted to:

1. Define and document existing property conditions.
2. Assist the Contractor and the Authority in resolving possible disputes over property conditions.

1.5 PRE-CONSTRUCTION INSPECTION

A. Prior to construction, conduct a preconstruction inspection survey of existing facilities, structures, and environmentally sensitive areas on or in the vicinity of the Worksite that may be damaged or adversely affected by construction activities. The inspection shall form the basis from which negative impacts such as new cracks, new damage, new settlement, and worsening of existing progressive cracks will be measured. Perform the following tasks and incorporate into the preconstruction inspection:

1. Document the inspection with videos, photographs, sketches, and narratives and assemble into an inspection report. Videos may include audio commentary.
2. Document existing conditions which may be damaged or adversely affected by construction activities.
3. Document vegetation densities, where applicable.
4. Document pre-existing damage, leaks, and cracks agreed to and documented by the Contractor and the Contracting Officer as pre-existing.

B. Coordinate with monitoring requirements specified in Section 31 09 13, Geotechnical Instrumentation and Monitoring.

C. Photographs shall comply with requirements specified in Section 02 21 33, Photographic Documentation. Video recordings shall comply with the requirements specified in Section 02 21 33, Photographic Documentation, under the Article entitled “Digital Video Recordings”.

1.6 PRODUCTS

Not Used.

1.7 EXECUTION

Not Used.

END OF SECTION

SECTION 02 41 00

DEMOLITION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Permits.

B. Site conditions.

C. Materials, equipment, and facilities.

D. Preservation of reference markers.

E. Demolition.

F. Removal.

G. Salvage.

H. Disposal of removed materials and debris.

1.2 RELATED SECTIONS

A. Removal of vegetation and trees and disposal of removed materials and debris are specified in Section 31 11 00, Clearing and Grubbing.

1.3 REFERENCE STANDARDS

A. American National Standards Institute (ANSI):

1. ANSI A10.6 Safety Requirements for Demolition Operations

B. State of California, Department of Transportation (Caltrans), Standard Specifications:

1. Section 15 Existing Highway Facilities
2. Section 15-4 Bridge Removal

1.4 REGULATORY REQUIREMENTS

A. In addition to the foregoing referenced standards, the regulatory requirements that govern the work of this Section include the following governing codes:

1. California Code of Regulations (CCR), Title 8, Chapter 4, Subchapter 4 – Construction Safety Orders.
2. California Code of Regulations (CCR), Title 24, Part 2, California Building Code, Chapter 33, "Safeguards During Construction".

B. Comply with codes and regulations of jurisdictional authorities.

1.5 DESCRIPTION

A. Demolition as follows:

1. Buildings and structure foundations, footings, and foundation systems shall be completely removed except as otherwise indicated.
2. Utility services to facilities to be removed or demolished shall be disconnected, cut, and capped.

B. Removal of pavements, curbs, gutters, sidewalks, posts, poles, pole foundations, structural steel and concrete, concrete foundations, fences, walls, utilities, utility structures and other facilities designated to be removed or the removal of which is necessary for the accomplishment of the Work.

C. Abandonment in-place of utilities and utility structures where indicated or where acceptable to the Contracting Officer.

D. Make arrangements with the appropriate utility owner for removal, rerouting of capping of utility where it is designated in the Contract Documents or required by utility owner policy for this work to be performed by the utility owner.

E. Demolish bridges in compliance with regulatory requirements, Contract requirements, and Caltrans Standard Specifications Section 15-4, Bridge Removal.

F. Divert demolition waste from landfill using such means as reuse and recycling in accordance with the Contract requirements.

1.6 PERMITS

A. Obtain special permits and licenses and give notices required for performance and completion of the demolition and removal work, hauling, and disposal of debris.

1.7 SUBMITTALS

A. Demolition Plan: Submit a comprehensive demolition plan, describing the proposed sequence, methods, and equipment for demolition, presence of any hazardous material, removal, and disposal of structure(s) and facilities; include salvage if required. Include compliance with regulations. Include procedures for backfilling, temporary support of structures, and shoring and underpinning, as applicable. Do not proceed with demolition prior to obtaining approval of the demolition plan. Cross-reference and coordinate demolition plan with submittals required for construction waste management and disposal, regarding salvaging and recycling removed and demolished materials. The following documents shall be included in the Demolition Plan as minimum requirements:

1. Shop Drawings: Include drawings in plan of all structures to be demolished. Indicate stages or phases of the demolition work.
2. Indicate materials and items to be salvaged and recycled.
3. Hazard Material Assessment per Contract requirements.
4. Well demolition and abandonment.
5. Rodent Control Program.

B. Permits: Submit copies of demolition, well abandonment, hauling, and debris disposal permits and notices for record purposes. Include description of proposed haul routes.

C. Utility Severance Certificates: Provide certificates, issued by the utility owners, of severance of utility services for record purposes.

D. Private Property Owner's Release: If material demolished and removed from the site will be deposited on private property, submit two copies of written releases not more than 15 days before the start of work. Releases shall absolve the Authority from responsibility in connection with the depositing of material on private property, and shall be signed by the owners of property on which the material will be deposited. Such disposal shall be per jurisdictional authority's requirements.

1.8 SITE CONDITIONS

A. Inspection of Buildings or Structures: Survey and inspect building or structure existing conditions before preparing Demolition Plan.

B. Protection of Persons and Property:

1. Install fencing, such as chain link, around the area of demolition work as required for protection of persons and property. Comply with applicable Contract requirements, including protective barricades and safety devices.
2. Provide safe passageways for the public around the demolition area and conduct operations to prevent injury to the public and damage to adjacent buildings, structures, and other facilities.
3. Erect and maintain temporary bracing, shoring, lights, barricades, signs, and other measures as necessary to protect the public, workers, and adjoining property from damage from demolition work, all in accordance with applicable codes and regulations.
4. Barricade open depressions and excavations occurring as part of this work and post with warning lights when accessible through adjacent property or through public access. Operate warning lights during hours from dusk to dawn each day and as otherwise required.
5. Protect sidewalks, utilities, streets, and facilities adjacent to the work from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by demolition operations. Do not leave sidewalks, utilities, streets, and facilities adjacent to the work in a condition that may cause damage or hazard to people or properties.
6. Repair or replace damaged items which are not designated for removal.

C. The Authority assumes no responsibility for the condition of the existing structures to be demolished.

D. Protection of Utilities:

1. Refer to Section 33 05 25, Support and Protection of Utilities. Protect active sewer, water, gas, electric, and other utilities; and drainage and irrigation lines indicated or, when not indicated, found or otherwise made known to the Contractor before or during demolition work. If utility is damaged, immediately notify the utility owner for corrective action. This protection shall apply to aerial and below-grade utilities and those within buildings and other structures.
2. Arrange with and perform work required by utility companies and municipal departments for discontinuance or interruption of utility services due to demolition work.

E. Noise and Dust Abatement: Comply with Contract requirements specified elsewhere, and the following:

1. Provide continuous noise and dust abatement as required to prevent disturbance and nuisance to the public and workers and to the occupants of adjacent premises and surrounding areas. Dampen or cover areas affected by demolition operations as necessary to prevent dust nuisance.
2. When removing portions of existing buildings (selective demolition), construct dustproof partitions inside building to separate areas where dirty or dusty operations are performed. Protect walls and floors with suitable coverings when necessary.
3. When a certain level of noise is unavoidable because of the nature of the work or equipment involved, and such noise is objectionable to the occupants of adjacent premises, make arrangements with the jurisdictional authorities to perform such work or operate such equipment at the most appropriate time periods of the day. Notify occupants of adjacent premises of demolition activities at least 72 hours prior to demolition work.

F. Unknown Conditions:

1. Below Grade Conditions and Concealed Conditions: Available information may represent surface and subsurface conditions at the site and adjoining areas. These surface and subsurface conditions shall be compared with actual conditions before commencement of work.
2. Locate, document, and protect existing utilities, drainage systems, and other facilities below grade as specified in Section 33 05 25, Support and Protection of Utilities.
3. Thicknesses of existing pavements, if indicated, are from previous construction documents, and do not imply the actual depth or thickness of the total pavement or base material, where it occurs.

PART 2 - PRODUCTS

2.1 MATERIALS, EQUIPMENT, AND FACILITIES

A. Furnish materials, tools, equipment, devices, appurtenances, facilities, and services as required for performing the demolition and removal work.

B. Materials used for backfill shall conform to the requirements for backfill of Section 31 05 00, Common Work Results for Earthwork.

C. Slurry Cement Backfill: Slurry cement backfill shall consist of a fluid, workable mixture of portland cement, clean and graded aggregate, and water.

PART 3 - EXECUTION

3.1 PRESERVATION OF REFERENCE MARKERS

A. Refer to Section 02 21 23, Field Engineering. Do not remove, relocate, or disturb survey markers and monuments found within the demolition area without prior written approval of the jurisdictional authorities or the written acceptance of the Contracting Officer, as applicable. Indicate survey makers needing relocation on the Demolition Plan.

B. Record the locations and designation of survey markers and monuments prior to their removal. Provide three reference points for each survey marker and monument removed, established by a licensed land surveyor currently registered in the State of California.

C. Store removed markers and monuments during demolition work, and replace them upon completion of the work. Re-establish survey markers and monuments in conformance with the recorded reference points. Submit a letter verifying re-establishment of survey markers and monuments, signed by a licensed civil engineer or land surveyor currently registered in the State of California.

3.2 DEMOLITION

A. Perform demolition in accordance with the approved Demolition Plan. Perform demolition work in accordance with ANSI A10.6 and the California Code of Regulations, Title 8 and Title 24, as applicable. Perform demolition in accordance with applicable rules of the jurisdictional authorities.

B. Utility Services to be Removed: Disconnect, cut, and cap utility services to facilities to be removed or demolished. Cap and plug pipe and other conduits abandoned due to demolition as required by the utility owners.

C. Backfill and compact depressions and voids caused by excavations, demolition, and removal in accordance with applicable requirements of Section 31 05 00, Common Work Results for Earthwork.

D. Buildings:

1. Demolish buildings in place, unless otherwise approved by the Contractor's engineer and jurisdictional authority.
2. Demolish in an orderly and careful manner, as required to accommodate new work and for connection to existing features. Protect existing structural members that need to remain.
3. Rebuild and repair, at Contractor's expense, demolition performed in excess of that required.

E. Unless otherwise indicated, dispose of building materials, fixtures, and equipment in, attached to or within, buildings and structures to be demolished.

F. Party Walls:

1. Where building wall being demolished is a party wall with another building not to be demolished, prevent damage to other building, and avoid interference with its occupants.
2. Restore and waterproof exposed party walls in accordance with applicable building code for exterior walls of particular type of construction involved.
3. Perform remedial measures for anchoring, bracing, or buttressing so that existing party walls do not become unsafe and dangerous because of demolition operation. If such work does not correct unsafe or dangerous conditions, remove and replace wall and perform necessary work to properly enclose structure that is to remain standing, at no cost to the Authority or to the owner of such property.

G. Perform selective demolition in accordance with requirements specified herein.

H. Refer to Section 31 11 00, Clearing and Grubbing, under Article entitled “Demolition/Removal”. Remove walls, masonry construction, and slabs to a minimum depth of 2 feet below existing ground level in areas where the Contractor’s engineer determines they are not detrimental to the structural integrity of the fill or structure to be placed above. Otherwise, completely remove walls, masonry construction, and slabs. Slabs shall be broken for drainage when left in place under the provisions of this Article.

I. Undertake rodent control and extermination program in demolition areas and adjacent surroundings.

3.3 REMOVAL

A. Perform removal work to extent shown and minimize damage to work which is to remain in place.

B. Repair existing surfaces, damaged during work, by cleaning and restoring to match existing.

C. Removal of Pavements, Sidewalk, Curbs, and Gutters

1. Remove existing pavements, structures, and site improvements that interfere with new construction, where demolition is not indicated. Coordinate as required with the work of Section 31 11 00, Clearing and Grubbing.
2. Demolish pavement, sidewalks, curbs, and gutters within demolition area shown to underside of pavement and dispose of resulting debris.
3. Fill resulting excavations, holes, and depressions to existing or new grade as shown using fill material conforming to requirements of Section 31 05 00, Common Work Results for Earthwork.
4. Adequately drain resulting surfaces.
5. Saw cut neat lines in concrete and asphalt concrete between demolition and existing to remain.

3.4 SALVAGE

A. Salvage or reuse materials and equipment as indicated on the Construction Specifications or Construction Drawings or elsewhere in the Contract requirements.

B. Protect finish of salvaged items during removal, transport, storage, and re-installation.

C. Clean salvaged items of foreign material, including adhered concrete, and store and protect from damage in or at accessible points within right-of-way or as shown in Construction Drawings.

D. Repair or replace salvaged items which are damaged or destroyed.

E. Where salvaged items are not designated for re-installation as part of the work of the Contract, deliver such materials to the Authority's or jurisdictional authority’s storage area. Prepare and maintain inventory of delivered salvaged items.

3.5 DISPOSAL OF REMOVED MATERIALS AND DEBRIS

A. Disposal of removed materials, waste, trash, and debris shall comply with requirements specified in Section 31 11 00, Clearing and Grubbing.

3.6 CLEANUP

A. Provide a clean and orderly site at all times.

END OF SECTION

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SECTION 03 05 15

PORTLAND CEMENT CONCRETE

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Portland cement.

B. Aggregates.

C. Drying shrinkage of concrete.

D. Concrete admixtures and cementitious materials.

E. Tests and analysis of materials.

F. Mix designs.

G. Batching, mixing, and transporting.

H. Inspection and Testing.

1.2 CLASSES OF CONCRETE

A. Classes of concrete are designated by numerical symbol indicating the minimum 28-day compressive strength, in pounds per square inch as determined by ASTM C39, and the maximum permissible size of coarse aggregate.

B. Each class of concrete may consist of one or more mixes determined by the maximum size of aggregate, cement factor, and types of admixtures or special aggregates used.

C. Each mix within a Class shall be considered a specific type, requiring acceptance of the mix design.

D. The various classes of concrete are listed in Table 03 05 15-A at the end of this Section.

1.3 DEFINITIONS

A. The word "concrete" followed only by a class designation (that is, Concrete Class 3000-1-inch) indicates normal weight aggregate concrete, such as concrete having a 28-day compressive strength of 3,000 psi, a maximum coarse aggregate size of 1 inch, and a minimum unit weight of 145 pounds per cubic foot (without reinforcement) at 28 Days.

B. The term "lightweight concrete" indicates lightweight structural concrete, which has a maximum unit weight of 115 pounds per cubic foot at 28 days.

C. The term "lean concrete" indicates a concrete containing the equivalent of two 94-pound sacks of cement per cubic yard.

D. The term “controlled density fill” indicates a flow-able mixture of aggregate and cementitious materials containing sufficient cement to develop a 28-day compressive strength of 50 to 150 psi.

E. The term "mass concrete" indicates any volume of concrete with dimensions large enough to require that measures be taken to cope with the generation of heat from hydration of the cement and attendant volume change in order to minimize shrinkage and cracking.

1.4 REFERENCED STANDARDS

A. American Concrete Institute (ACI):

1.	ACI 117	Specification for Tolerances for Concrete Construction and Materials
2.	ACI 121R	Guide for Concrete Construction Quality Systems in Conformance with ISO 9001
3.	ACI 211.1	Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete
4.	ACI 211.2	Standard Practice for Selecting Proportions for Structural Lightweight Concrete
5.	ACI 213R	Guide for Structural Lightweight-Aggregate Concrete
6.	ACI 301	Specifications for Structural Concrete
7.	ACI 304R	Guide for Measuring, Mixing, Transporting, and Placing Concrete
8.	ACI 304.2R	Placing Concrete by Pumping Methods
9.	ACI 305R	Guide to Hot Weather Concreting
10.	ACI 306.1	Standard Specification for Cold Weather Concreting
11.	ACI 318	Building Code Requirements for Structural Concrete and Commentary

B. ASTM International (ASTM):

1.	ASTM C31	Standard Practice for Making and Curing Concrete Test Specimens in the Field
2.	ASTM C33	Standard Specification for Concrete Aggregates
3.	ASTM C39	Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
4.	ASTM C40	Standard Test Method for Organic Impurities in Fine Aggregates for Concrete
5.	ASTM C42	Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
6.	ASTM C88	Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
7.	ASTM C94	Standard Specification for Ready-Mixed Concrete
8.	ASTM C114	Standard Test Methods for Chemical Analysis of Hydraulic Cement
9.	ASTM C117	Standard Test Method for Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
10.	ASTM C123	Standard Test Method for Lightweight Particles in Aggregate
11.	ASTM C127	Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
12.	ASTM C128	Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate
13.	ASTM C131	Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
14.	ASTM C136	Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates

15. ASTM C142 Standard Test Method for Clay Lumps and Friable Particles in Aggregates
16. ASTM C143 Standard Test Method for Slump of Hydraulic Cement Concrete
17. ASTM C150 Standard Specification for Portland Cement
18. ASTM C157 Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete
19. ASTM C172 Standard Practice for Sampling Freshly Mixed Concrete
20. ASTM C231 Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
21. ASTM C289 Standard Test Method for Potential Alkali-Silica Reactivity of Aggregates (Chemical Method)
22. ASTM C330 Standard Specification for Lightweight Aggregates for Structural Concrete
23. ASTM C470 Standard Specification for Molds for Forming Concrete Test Cylinders Vertically
24. ASTM C490 Standard Practice for Use of Apparatus for the Determination of Length Change of Hardened Cement Paste, Mortar, and Concrete
25. ASTM C494 standard Specification for Chemical Admixtures for Concrete
26. ASTM C535 Standard Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
27. ASTM C618 Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
28. ASTM C979 Standard Specification for Pigments for Integrally Colored Concrete
29. ASTM C1017 Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete
30. ASTM E329 Standard Specification for Agencies Engaged in the Construction Inspection, Special Inspection, or Testing Materials Used in Construction

1.5 DESCRIPTION

A. Portland cement concrete shall be composed of portland cement, fine aggregate, coarse aggregate, and water, with or without supplementary cementitious materials and admixtures as approved by the Contractor’s engineer, proportioned and mixed as specified herein.

1.6 SUBMITTALS

A. Concrete Mix Designs: Submit mix designs as herein specified in Article entitled “Mix Designs”. Include laboratory test reports of trial strength and shrinkage tests. Submit mix designs a minimum of 30 days prior to batching or delivering concrete.

B. Product Data: Submit manufacturer's product data for proposed concrete admixtures.

C. Aggregate Source: Submit aggregate source.

D. Affidavits/Certificates: For each shipment of materials, submit evidence of compliance with Specification requirements for cement, aggregate, supplementary cementitious materials, and admixtures. Mill tests and manufacturers' certification of compliance with ASTM Specifications may be accepted in lieu of testing of cement and analysis of aggregates. Certificates of Compliance shall be signed by the materials manufacturer and the Contractor.

E. Batch Tickets: Submit a delivery ticket with each batch of concrete delivered to the site in accordance with the requirements of ASTM C94.

F. Submit for the name, address, and telephone number of the laboratory, agency, mill, or ready-mix plant, which the Contractor intends to engage to design the concrete mixes and for testing.

1.7 QUALITY ASSURANCE/CONTROL

A. Select a qualified concrete supplier capable of meeting project requirements and the requirements of these Specifications.

B. The concrete supplier shall be certified by the National Ready Mix Concrete Association and shall hold a valid certificate of conformance for concrete production facilities.

C. Mix designs shall be obtained by the Contractor from a qualified independent testing laboratory or agency, or from a mill or ready-mix plant, properly equipped to design concrete mixes. The design shall be performed and certified by a professional engineer currently registered as a civil or structural engineer in the State of California. The laboratory, agency, mill, or ready-mix plant shall meet applicable requirements of ASTM E329.

D. Contractor's Quality Management Plan shall ensure control and uniformity of materials, conformance with accepted mix designs, and prompt and proper delivery of concrete to the jobsite in accordance with applicable requirements of ASTM C94. Include in the plan all tests the Contractor will perform to verify compliance with Specification requirements, and the independent laboratory the Contractor intends to engage to perform the tests.

E. Samples: Make cement and aggregates available for the Contracting Officer's sampling at least 30 days prior to use in the Work.

1.8 ENVIRONMENTAL REQUIREMENTS

A. Hot Weather Concreting:

1. Batching, mixing, and delivering of concrete in hot weather shall conform to the applicable requirements of ACI 305R.
2. Maximum ambient temperature for placing concrete shall be 90 degrees F. If the ambient temperature exceeds 90 degrees F, the mix shall be cooled by an appropriate method approved by the Contractor's engineer, such as icing the mixing water. Maintain uniform concrete temperature of succeeding batches placed.

B. Cold Weather Concreting:

1. Batching, mixing, and delivering of concrete in cold weather shall conform to the applicable requirements of ACI 306.1.
2. When the ambient temperature drops below 35 degrees F, or is expected to drop below 35 degrees F during placement, the temperature of the mix shall be heated by adding hot water, not exceeding 120 degrees F, or by steam heating the aggregates, or both. Other methods of heating aggregates will not be permitted. Steam heating the aggregates may require an adjustment in the mixing water.
3. All concrete shall be protected against freezing for at least 36 hours after placing.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Portland Cement: ASTM C150, Type II, low alkali. Type III Portland cement may be used where high early strength concrete is a requirement as approved by the Contractor's engineer.

B. Aggregates:

1. Coarse Aggregate: ASTM C33, clean and uniformly graded from 3/8 inch to maximum size indicated or specified. When not specified, provide 1-inch maximum size (ASTM C33, Size No. 57). Deleterious materials in aggregates shall not exceed the limits specified in ASTM C33.
2. Fine Aggregate: ASTM C33, uniformly graded from 3/8 inch to fines, washed clean. Deleterious materials in fine aggregates shall not exceed the limits specified in ASTM C33.
3. Lightweight Aggregates: ASTM C330, uniformly graded to maximum size indicated or specified. When not specified, provide 3/4-inch to No. 4 coarse aggregate combined with ASTM C33 graded fine aggregate.
4. Aggregate for Exposed Concrete: Aggregate for concrete, which will be exposed to the public shall be obtained from one source for each type of aggregate required in order to produce a uniform color.

C. Special Aggregates for Reducing Shrinkage and Creep: Cast-in-place reinforced concrete used for underground structures critical to continued main track operations, concrete for post-tensioned cast-in-place concrete and for precast, prestressed concrete, and for topping slabs shall be produced with special aggregates conforming to the following requirements:

1. Source of Aggregates: Aggregates shall be obtained from a selected aggregate source, known to produce aggregates complying with the specified requirements, as accepted by the Contracting Officer.
2. Coarse Aggregate:
   a. Coarse aggregate shall consist of hard, dense, durable crushed or uncrushed gravel or crushed aggregate conforming to ASTM C33 and the herein specified requirements. Deleterious substances in aggregates shall not exceed the following limits:

Deleterious Material	Percentage by Weight
Material Passing No. 200 Sieve (ASTM C117):	
Nominal size range No. 4 to 3/4 inch:	0.5
Nominal size range 3/4 inch to 1-1/2 inches:	0.4
Shale (ASTM C123, specific gravity of heavy liquid 1.95):	1.0
Clay lumps (ASTM C142):	0.5
Other deleterious substances:	1.0
Total of all deleterious substances:	3.0

b. Coarse aggregate shall conform to the following requirements when tested in accordance with the specified ASTM Test Methods:
  1) Resistance to Abrasion (ASTM C131): The loss for aggregate size range 3/4 inch to 3/16 inch after 100 revolutions and 500 revolutions shall not exceed 10 percent and 40 percent, respectively. The test sample shall consist of 7 parts of grading B and 3 parts of grading C.
  2) Resistance to Abrasion (ASTM C535): The loss for aggregate size range 1-1/2 inches to 3/4 inch (grading 3) after 200 revolutions and 1000 revolutions shall not exceed 10 percent and 40 percent, respectively.
  3) Soundness (ASTM C88): Weighted average loss after 5 cycles shall not exceed 12 percent when tested with sodium sulfate.
  4) Specific Gravity (ASTM C127): Bulk specific gravity on the basis of saturated surface-dry aggregate shall be not less than 2.60.
  5) Absorption (ASTM C127): Absorption shall not exceed 3 percent.
  6) Potential Reactivity (ASTM C33): Only aggregates considered innocuous in accordance with Appendix XI shall be used in the work.

3. Fine Aggregate:
  a. Fine aggregate shall consist of hard, dense, durable, stone or rock fragments conforming to ASTM C33 and the herein specified requirements. Deleterious substances in aggregate shall not exceed the following:

Deleterious Material	Percentage by Weight
Material Passing No. 200 Sieve (ASTM C117):	3.0
Shale (ASTM C123, specific gravity of heavy liquid 1.95):	1.0
Clay lumps (ASTM C142):	1.0
Total of other deleterious substances (such as alkali, mica, coated grains, soft flaky particles, and loam):	2.0
Total of all deleterious substances:	5.0

  b. Fine aggregate shall conform to the following requirements when tested in accordance with the specified ASTM Test Methods:
    1) Specific Gravity (ASTM C128): Not less than 2.60 on a saturated surface-dry basis.
    2) Organic Impurities (ASTM C40): Supernatant liquid must be lighter in color than the reference standard color solution.
    3) Soundness (ASTM C88): Loss in 5 cycles of sodium sulfate test shall not exceed 12 percent.
    4) Potential Reactivity (ASTM C289): Only fine aggregate considered innocuous shall be used in the work.
    5) Fineness Modulus (ASTM C33): Fineness modulus shall be in the range of 2.30 to 3.00, however, the variation of the fineness modulus shall not exceed 0.20.

4. Drying Shrinkage of Concrete:
  a. A trial batch of the proposed (mix design) concrete shall be prepared using the aggregates, cement, and admixture proposed for this work. From the trial batch, three specimens (4 inches by 4 inches by 11 inches) for determining "Drying

Shrinkage" shall be prepared, cured, dried, and measured as specified in ASTM C157 and ASTM C490, with the following modifications:

1) Cast-in-place concrete shall be moist cured for 10 days.
2) Precast, prestressed concrete shall be steam cured for 1 day.
3) Measurements shall be made and reported for 7, 14, 21, and 28 days of drying after 9 days of moist curing and 1 day of steam curing.

b. Shrinkage of specimens for cast-in-place concrete shall not exceed 0.040 percent when measured in accordance with ASTM C157 and ASTM C490 after 21 days of drying.

c. Shrinkage of specimens for prestressed concrete shall not exceed 0.035 percent when measured in accordance with ASTM C157 and ASTM C490 after 21 days of drying.

D. Concrete Admixtures and Cementitious Materials: Contractor may include accepted concrete admixtures and cementitious materials in the mix to improve the water-cement ratio or water-cementitious ratio, workability of the concrete, or other required characteristics, providing the strengths specified and other desirable characteristics of the concrete can be achieved and maintained. Admixtures require the Contracting Officer's acceptance before they may be used, and shall be included in the design mix, introduced in solution form. Admixtures shall be added at the batch plant, except as otherwise noted herein.

1. Chemical Admixtures, Water-Reducing: ASTM C494, Type A.
2. Pozzolanic Admixtures: ASTM C618, Class N or F.
3. Fly Ash: ASTM C618, Class F, with a maximum of 25 percent retained on the No. 325 mesh sieve and a loss on ignition of 1.0 percent maximum.
4. Pigments for integrally colored concrete: ASTM C979, for synthetic or natural iron oxides (red).
5. Chemical Admixtures, Plasticizing: ASTM C1017, or ASTM C494 Type F or Type G, high-range water-reducing admixtures.
6. Prohibited Admixtures: Admixtures containing chlorides or sulfides are not acceptable.

E. Water: Water for concrete mixes, curing, and cleaning shall be clean and potable, free of impurities detrimental to concrete.

F. Reinforcement Fibers: Chopped strands of alkali-resistant polypropylene fibers added to the concrete mix for protection against shrinkage cracks where indicated or required.

2.2 TESTS AND ANALYSES OF MATERIALS

A. Tests and Sample Analyses: Testing of cement and analysis of aggregates shall be performed by the Contractor as specified herein. Mill tests and supplier's certification of compliance with ASTM Specifications will be accepted in lieu of testing of cement and analysis of aggregates. Tests and services shall consist of the following:

1. Testing of portland cement in accordance with ASTM C150 and ASTM C114.
2. Analysis of aggregates in accordance with ASTM C33, and sieve analysis of fine and coarse aggregates in accordance with ASTM C136.
3. Tests of special aggregates for reducing shrinkage and creep shall conform to the requirements herein specified under Article entitled "Materials".

B. Samples: Contractor's employed independent testing laboratory shall select samples of materials required for tests and analysis at random. Test samples of cement and aggregates at least 30 days prior to use on the project.

2.3 MIX DESIGNS

A. Selection of mix proportions shall conform to the applicable requirements of ACI 211.1 and ACI 211.2. Concrete shall comply with ACI 301 and ACI 318, as applicable. Ensure that mix designs will produce concrete suited for proper placement and finishing. Design of concrete mixes shall include recommended amounts of admixture and water to be used in the mixes.

B. Mix design for subway structures and below-grade retaining walls for stations and other facilities shall include 15 percent replacement of the cement with fly ash, along with a plasticizing admixture conforming to ASTM C1017, to provide a dense and plastic concrete with low shrinkage and permeability characteristics.

C. Mix design for architectural concrete and formed concrete which will be exposed to the public in the finished work shall include 10 percent replacement of the cement with fly ash along with a plasticizing admixture, conforming with ASTM C1017, to provide a dense and plastic concrete mix which completely fills out the forms and form detail without air holes and rock pockets.

D. Mix designs shall indicate brands, types, and quantities of admixtures included. If fly ash is proposed, it shall be identified as such (for example, "fly ash"), and the mix design shall identify the percentage of cement replacement and the locations in the structures where such mixes are proposed for use.

E. Mix designs for integrally colored concrete shall indicate brand type of natural or synthetic metallic oxide or pigment, and quantity used, all prepared as specified in ASTM C979. Compensate for fly ash with additional pigment as applicable. Concrete encasements of below-grade electrical conduits and ductbanks containing circuits over 600 Volts shall be integrally colored red concrete.

F. Refer to Section 03 70 00, Mass Concrete, for mix design requirements for mass concrete.

G. If concrete is to be placed by pumping, concrete mixes shall be designed in accordance with the applicable requirements of ACI 304R and ACI 304.2R, and shall include strengths and slumps.

H. Mix design for controlled density fill (controlled low strength material) to be used for structural backfill for utility trenches and pipe culverts shall contain approximately 20 to 30 pounds of cement per cubic yard along with fly ash in amount required to provide a workable mixture. The 28-day compressive strength shall be not less than 50 psi or more than 150 psi. Soil or aggregate component shall be an inert material without organic matter, all passing a 1-inch sieve.

I. Mix designs shall indicate location of each mix within the structures.

J. Mix designs shall specify both coarse and fine aggregate sources.

K. Concrete mixes shall contain the minimum number of 94-pound sacks of cement per cubic yard specified in Table 03305-A, regardless of the fact that the strengths specified may be obtained with lesser amounts of cement. Exception will be made only for mass concrete to reduce heat of hydration as hereinbefore specified.

L. The water-to-cement ratio shall not exceed 0.40 for concrete, which may be exposed to underground water, such as subway and station structures and for concrete in structures critical to continued main track operations. Conversion to equivalent water-to-cementitious ratio shall be performed in accordance with applicable requirements of ACI 211.1.

M. Concrete for ductbanks shall have a 28-day compressive strength of 3,000 psi, minimum.

2.4 BATCHING, MIXING, AND TRANSPORTING

A. Batching, mixing, and transporting portland cement concrete shall conform to the applicable requirements of ACI 301 and ACI 304R.

B. Concrete shall be central-mixed concrete from a central batch plant, to be transported to the jobsite in a truck mixer, in accordance with the requirements of ASTM C94. Equipment used in the manufacture of concrete shall be kept clean at all times.

C. Mixers shall be equipped with automatic device for recording number of revolutions of drum prior to completion of mixing operation. Each transit mixer shall also be equipped with water measuring devices consisting of either accurately calibrated water tanks or water meters.

D. Concrete in truck mixer shall be mixed continuously until discharged. The discharge time for concrete after the introduction of mixing water shall not exceed 60 minutes. The discharge time for concrete after cement has been mixed with aggregate shall not exceed 90 minutes. Delivery tickets shall show departure time from plants.

E. Ready-mixed concrete shall be mixed for a period of not less than 10 minutes and at least 3 minutes of the mixing period shall be immediately prior to discharging at the job. The introduction of additional water into transit type mixers after leaving the plant shall not be permitted.

PART 3 - EXECUTION

3.1 FIELD QUALITY CONTROL

A. Inspection and Testing Services:

1. Visual inspections and acceptance of concrete mix designs will be by the Contractor’s engineer. The Contractor’s engineer shall observe concrete batching, mixing, and placing operations, and the Contractor shall keep records of all concrete placed. Submit, under Section 03 30 00, Cast-in-Place Concrete, records of all concrete placed.
2. Testing services for the Contractor's quality control program, including concrete strength tests, shall be provided by an independent testing laboratory or agency, employed by the Contractor, and shall be performed in accordance with the applicable requirements of ACI 301. If, as a result of these tests, it is determined that the specified concrete properties are not being obtained, the Contractor’s engineer shall order such changes in proportions or materials, or both, as may be necessary to secure the specified properties.
    a. Field tests shall be performed by personnel having ACI Level 1 Field Technician Certification.

3. Provide materials, labor, and services for sampling and testing of concrete, including the following facilities and services:

a. Preparation, handling, storage, and delivery of concrete test specimens.
b. Suitable containers for the storage, curing, and delivery of concrete test specimens in accordance with ASTM C31 and ASTM C470.
c. Suitable storage for a supply of test cylinder molds, test specimens to be cured at the jobsite, and other items required for sampling and testing.

B. Methods of Sampling and Testing:

1. Sampling: Representative composite samples shall be taken in accordance with ASTM C172. Each sample shall be obtained from a different batch of concrete on a random basis.
2. Slump Tests: The above-specified Contractor employed testing laboratory shall perform slump tests of concrete during placing of concrete, as required, in accordance with ASTM C143. At least one test shall be performed at the delivery trucks for each 50 cubic yards of concrete delivered.
3. Tests for Concrete Uniformity: The same testing laboratory shall perform tests for concrete uniformity in accordance with ASTM C94, Annex A1. Each batch of concrete shall be tested as specified in ASTM C94, Annex A1.
4. Tests for Concrete Temperature: Freshly mixed concrete shall be tested hourly when the ambient temperature is below 40 degrees F and above 80 degrees F, and each time compression test cylinders are made. The concrete temperature shall be recorded on all compression test cylinders made. Refer to Article entitled “Environmental Requirements” herein for hot and cold weather remedial requirements.
5. Strength Tests:
   a. Prepare, cast, and deliver to the same independent testing laboratory, cylinders for laboratory-cured compression test samples. Cylinders shall be made and cured in accordance with ASTM C31. Cylinders shall be tested in accordance with ASTM C39.
   b. The minimum number of test cylinders to be made for each class of concrete and for each placement shall be four cylinders for each 100 cubic yards or fraction thereof. When additional sets of test cylinders are required beyond the normal 7- and 28-day tests, each set shall consist of a minimum of two test cylinders.
   c. All cylinders in a set shall be marked with a unique number on one end. Record this number on the record of concrete placed. All cylinders shall be cured by the Contractor’s independent testing laboratory.
   d. From each set of cylinders cast, one cylinder shall be tested at 7 days and two cylinders at 28 days in accordance with ASTM C39. If the 28-day tests are satisfactory, the fourth cylinder shall be discarded.
   e. In the event the 28-day tests are below the specified strength requirements, the Laboratory shall then test the fourth cylinder at the age selected by the Contractor’s engineer.

6. Tests for Contractor's Benefit: Tests required to verify early form removal, or other reasons for the Contractor's benefit, shall be performed at Contractor's expense as part of the Contractor's quality control program.

C. Evaluation and Acceptance of Tests:

1. Acceptance of Concrete: The strength of the concrete shall be considered satisfactory, provided the averages of all sets of three consecutive strength test results equal or exceed the specified 28-day compressive strength, and no individual strength test result falls below the specified 28-day compressive strength by more than 500 psi.

2. Adjustments: The Contractor’s independent testing laboratory shall order adjustments to the mix proportions, increase in the minimum cement content, additional curing of the structure, or any combination of the above when strength tests acceptance criteria specified are not being met.
3. Test Cores:
    a. When laboratory test results indicate concrete to be more than 300 psi below the specified strength, or if there is a likelihood of low strength concrete, a significant reduction in load-carrying capacity, or absence of desired durability in the concrete, the Contractor’s engineer shall require tests of cores to be drilled from the areas in question.
    b. Test cores shall be obtained from each member or area of suspect strength, from locations designated by the Contractor’s engineer, and test specimens shall be prepared by the Contractor in accordance with ASTM C42.
    c. Three cores shall be taken for each determination of in-place strength. Concrete in the area represented by the core tests will be considered structurally adequate if the average of the three cores is equal to at least 85 percent of the specified design strength and no single core is less than 75 percent of the design strength. Locations represented by erratic core strengths shall be retested under the direction of the Contractor’s engineer.
    d. Fill core holes in accordance with the requirements of Section 03 35 00, Concrete Finishing, for repair of surface defects.

4. Rejection of Concrete; Repair and Replacement: Reject concrete work, which does not meet specification requirements, and to require repair or replacement as necessary to complete the Work.

D. Acceptance of Structure: Acceptance of the completed concrete work requires conformance with the dimensional tolerances, appearance, and strengths specified in these Specifications, in ACI 301, and in ACI 117.

3.2 SCHEDULES

TABLE 03 05 15-A
PORTLAND CEMENT CONCRETE MIXES

CLASSIFICATION		MINIMUM CEMENT CONTENT
Compressive Strength (psi) at 28 days	Maximum Aggregate Size	94-Pound Sacks per cubic yard
A. Reinforced Concrete:		
2500	3/8 inch	5.0
2500	1 inch	4.5
2500	1-1/2 inch	4.5
3000	3/8 inch	5.5
3000	1 inch	5.0
3000	1-1/2 inch	5.0
3500	3/8 inch	6.0
3500	1 inch	5.5
3500	1-1/2 inch	5.0
4000	3/8 inch	6.5
4000	1 inch	6.0
4000	1-1/2-inch	5.5
4500	3/8 inch	7.0
4500	1 inch	6.5
4500	1-1/2 inch	6.0
5000	3/8 inch	7.0
5000	1 inch	6.5
B. Prestressed Concrete:		
5000	1 inch	7.0
6000	1 inch	7.5

END OF SECTION

SECTION 03 05 18

PRESTRESSED CONCRETE

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Concrete Works.

B. Duct Work.

C. Jacks.

D. Tendons.

E. Grouting.

F. Stress Transfer.

G. Field Quality Control.

H. Forming and Repair of Holes and Blockouts.

I. Protection of Post-Tensioning Anchorages.

1.2 DESCRIPTION

A. This Section describes constructing aerial structures by prestressing precast or cast-in-place concrete by furnishing, placing, and tensioning of prestressing steel; and includes prestressing either by pretensioning or post-tensioning methods or a combination of both methods. The Work includes furnishing and installing prestressed concrete members complete in place, including concrete, prestressing steel, reinforcing steel, and appurtenant items necessary for the particular prestressing system to be used, including ducts, anchorage assemblies, and grout used for pressure grouting ducts.

1.3 RELATED SECTIONS

A. Section 03 05 15, Portland Cement Concrete.

B. Section 03 11 00, Concrete Forming.

C. Section 03 11 14, Falsework.

D. Section 03 20 00, Concrete Reinforcing.

E. Section 03 30 00, Cast-In-Place Concrete.

F. Section 03 35 00, Concrete Finishing, except as modified herein for precast, prestressed concrete.

G. Section 03 40 00, Precast Concrete.

H. Section 03 43 00, Precast Concrete Segmental Construction.

I. Section 03 62 00, Non-Shrink Grouting.

1.4 REFERENCE STANDARDS

A. American Association of State Highway and Transportation Officials (AASHTO):

1. AASHTO LRFDCONS Load and Resistance Factor Design (LRFD) Bridge Construction Specifications
2. AASHTO LRFDUS Load and Resistance Factor Design (LRFD) Bridge Design Specifications

B. American Concrete Institute (ACI):

1. ACI 301 Specifications for Structural Concrete
2. ACI 318 Building Code Requirements for Structural Concrete
3. ACI 503R Use of Epoxy Compounds with Concrete

C. ASTM International (ASTM):

1. ASTM A36 Standard Specification for Carbon Structural Steel
2. ASTM A123 Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
3. ASTM A153 Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
4. ASTM A240 Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
5. ASTM A370 Standard Test Methods and Definitions for Mechanical Testing of Steel Products
6. ASTM A416 Standard Specification for Steel Strand, Uncoated Seven-Wire for Prestressed Concrete
7. ASTM A722 Standard Specification for Uncoated High-Strength Steel Bars for Prestressing Concrete
8. ASTM C957 Standard Specification for High-Solids Content, Cold Liquid-Applied Elastomeric Waterproofing Membrane with Integral Wearing Surface
9. ASTM C1152 Standard Test Method for Acid-Soluble Chloride in Mortar and Concrete
10. ASTM D395 Standard Test Methods for Rubber Property – Compression Set
11. ASTM D412 Tension Test for Vulcanized Rubber and Thermoplastic Elastomers
12. ASTM D471 Standard Test Method for Rubber Property – Effect of Liquids
13. ASTM D570 Standard Test Method for Water Absorption of Plastics
14. ASTM D573 Standard Test Method for Rubber Deterioration in an Air Oven
15. ASTM D638 Standard Test Method for Tensile Properties of Plastics
16. ASTM D1000 Standard Test Methods for Pressure-Sensitive Adhesive-Coated Tapes Used for Electrical and Electronic Applications
17. ASTM D1171 Standard Test Method for Rubber Deterioration – Surface Ozone Cracking Outdoors or Chamber (Triangular Specimens)
18. ASTM D2137 Standard Test Methods for Rubber Property – Brittleness Point of Flexible Polymers and Coated Fabrics
19. ASTM D2240 Standard Test Method for Rubber Property – Durometer Hardness

20. ASTM D3035 Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter
21. ASTM D3350 Standard Specification for Polyethylene Plastics Pipe and Fittings Materials
22. ASTM D3895 Standard Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry
23. ASTM D4101 Standard Specification for Polypropylene Injection and Extrusion Materials
24. ASTM D5989 Standard Specification for Extruded and Monomer Cast Shapes Made from Nylon (PA)
25. ASTM E28 Standard Test Methods for Softening Point of Resins Derived from Naval Stores by Ring-and-Ball Apparatus
26. ASTM F714 Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter
27. ASTM F2136 Standard Test Method for Coated Fabrics – Low-Temperature Bend Test

D. American Welding Society (AWS):

1. ANSI/AWS D1.1 Structural Welding Code – Steel
2. ANSI/AWS D1.4 Structural Welding Code – Reinforcing Steel

E. Military Specifications

1. MIL-PRF-3420 Wrapping Materials, Volatile Corrosion Inhibitor Treated, Opaque

F. International Federation of Structural Concrete (FIB)

1. FIB Bulletin 7 Technical Report, “Corrugated Plastic Ducts for Internal Bonded Post-Tensioning”

G. State of California Department of Transportation Standard Specifications (Caltrans):

1. Section 50 Prestressing Concrete,
2. Section 52 Reinforcing

H. Precast/Prestressed Concrete Institute (PCI):

1. PCI Design Handbook Precast and Prestressed Concrete
2. PCI MNL 116 Manual for Quality Control for Plants and Production of Structural Precast Concrete Products
3. PCI MNL 117 Manual for Quality Control for Plants and Production of Architectural Precast Concrete Products
4. PCI MNL 122 Architectural Precast Concrete

I. Post-Tensioning Institute (PTI):

1. PTI Publication Post-Tensioning Manual
2. PTI Publication Guide Specification for Grouting of Post-Tensioned Structures

1.5 PREINSTALLATION MEETINGS

A. Pre-Grouting Meeting: Before grouting operations begin, conduct a joint meeting of the Contractor, the Contractor's engineer, and grouting crew. At this meeting, the Grouting Operations Plan, required testing, corrective procedures, and other relevant issues shall be discussed.

1.6 SUBMITTALS

A. Test Results and Certification Regarding Proposed Post-Tensioning System: As specified under "Quality Assurance" herein.

B. Shop Drawings: Submit complete shop drawings and necessary calculations for formwork, falsework, and fabrication of precast structural products and prestressed structural products. Drawings and calculation shall be prepared under the supervision of and signed and sealed by a California licensed Professional Engineer. The design of for precast or prestressed structural products or both shall include self-stressing forms, bed abutments, and anchorages.

1. Submit information on capacity of each bed and self-stressing form, in terms of allowable prestress force and corresponding center of gravity above form base.
2. Include compensation for deflection as necessary to construct structure to lines and grades shown.
3. Consider loads, forces, and stresses to be imposed during casting and prestressing elements of the structure.
4. List of components.

C. Safety Plans. Include safety measures to prevent accidents due to possible breaking of prestressing steel or slipping of grips during tensioning process.

D. Submit a Grouting Operations Plan for approval at least 6 weeks in advance of scheduled grouting operations.

1. Include proposed Grouting Report form.

E. Product Data: Submit the following product data:

1. Grout.
2. Elastomeric coating system.
3. Certified test reports and manufacturer's certification of proposed grout. As specified under "Quality Assurance" herein.

F. Certification:

1. Submit certification that the post-tensioning system being furnished is in compliance with all requirements stated herein.
2. Prestressing Steel: Manufacturer's certificates shall accompany each shipment.
3. Hydraulic Jacks: Submit certified calibration curves for each hydraulic jack.
4. Certified Test Reports:
   a. Concrete Tests.
   b. Prestressing Steel: For each size of strand and wire to be used in the Work, submit test certificates showing physical, chemical and stress/strain test properties including

modulus of elasticity, and stating guaranteed minimum ultimate tensile and yield strength.

c. Submit Quality Control Data Sheet for each lot number and shipment delivered to the job site.

5. Upon completion of post-tensioning installation, provide a certification that the PT system supplied was installed without modification and met the requirements of the Contract Documents.

G. Grouting Report: Submit Grouting Report within 72 hours of each grouting operation.

H. Field Test Reports: Submit reports of field quality control testing and records of stressing operations.

I. Elastomeric Coating Applicator Qualifications: Submit the credentials of proposed applicators.

J. Prestressing Firm Qualifications: Submit the credentials of proposed firm.

1.7 QUALITY ASSURANCE

A. General: Refer to Contract requirements for quality assurance requirements and procedures.

B. Obtain Contractor's engineer's approval of proposed post-tensioning systems. In order to facilitate the Contractor's engineer's evaluation of post-tensioning systems, submit the following test results:

1. Include certified test reports from an independent laboratory audited by AASHTO Materials Reference Laboratory (AMRL) which shows the post-tensioning system meets all the requirements specified herein.
2. Include certified test plastic components. Test reports shall be from a certified independent laboratory accredited through the laboratory accreditation program of the Geosynthetic Accreditation Institute (GAI) or the American Association for Laboratory Accreditation (A2LA).
   a. Include certification that the plastic from the duct sample complies with all requirements of the specified cell class, stress crack rating and the specified amount of antioxidant.

C. Certification of test reports may be performed by an independent laboratory located outside the U.S., if the independent laboratory is accepted by the Contracting Officer.

D. Obtain Contractor's engineer's approval of proposed grout. In order to obtain Contractor's engineer's evaluation of grout, submit test results to the Contractor's engineer.

1. Include certified test reports from an independent laboratory audited by the Cement and Concrete Reference Laboratory (CCRL) which shows the material meets the requirements specified herein.
2. Submit a written certification from the manufacturer that the product meets the requirements of this Section. Grout products will be qualified by application (horizontal, vertical or repair).

E. Modifications to Post-Tensioning System, Including Grout:

F. If any component of the post-tensioning system is modified or replaced, the appropriate component test and entire system test, if needed, shall be performed in accordance with the requirements herein and an updated submittal made to the Contractor's engineer containing the test reports and revised system drawings. Before attempting to change post-tensioning system components contact the Contractor's engineer for approval.

  1. For grout, if any change of materials or material sources component is proposed, the appropriate tests, if needed, shall be performed in accordance with the requirements herein and an updated submittal application made to the Contractor's engineer containing the test reports. Before proposing such change, contact the Contractor's engineer for approval.

G. Governing Standards:

  1. AASHTO Bridge Design Specifications with Caltrans amendments.
  2. Precast/Prestressed Concrete Institute: Comply with the requirements of PCI Manual 116 and PCI Design Handbook – "Precast and Prestressed Concrete," as applicable.
  3. Post-Tensioning Institute (PTI): Comply with the requirements of PTI "Post-Tensioning Manual," as applicable.
  4. ACI 301 Section 9.
  5. Precast, Prestressed Concrete: Comply with requirements of Section 03 40 00, Precast Concrete, as applicable to the precast and erection portions of the Work.

H. Prestressing work shall be performed by a specialist firm or organization that has successfully performed previous installations of structures similar to the Work of the Contract within the last 5 years.

I. Welders shall be prequalified in accordance with AWS D1.1, Chapter 5 or AWS D1.4 Chapter 6, as applicable to the Work.

J. Elastomeric Coating Applicators: Apply epoxy coatings using approved and experienced personnel with a minimum of 3 years of experience applying similar polyurethane systems.

K. Elastomeric Coating Mockup: Construct a 2-foot by 4-foot concrete test block with a similar surface texture to the surfaces to be coated, and coat a vertical face with the elastomeric coating system. Determine the number of coats required to achieve a coating thickness between 30 to 45 mils without runs and drips. Demonstrate means of application proposed to be employed in the Work. Spray or roll application is permitted (spray application preferred). Have the coating manufacturer's representative on site to supervise and comment on the application of the elastomeric coating onto the test block.

1.8 DEFINITIONS

A. Anchorage Assembly: An assembly of various hardware components which secures a tendon at its ends after it has been stressed and, imparts the tendon force into the concrete.

B. Anticipated Set: The wedge set assumed to occur in the design calculation of the post-tensioning forces at the time of load transfer.

C. Bar: Post-tensioning bars are high strength steel bars, normally available from 5/8 to 1 3/4 inch diameter and usually threaded with very coarse thread.

D. Bearing Plate: Any hardware that transfers the tendon force directly into a structure or the ground.

E. Bleed: The autogenous flow of mixing water within or its emergence from, newly placed grout, caused by the settlement of the solid materials within the mass.

F. Coupler: A device used to transfer the prestressing force from one partial length prestressing tendon to another. (Strand couplers are not permitted.)

G. Duct: Material forming a conduit to accommodate prestressing steel installation and provide an annular space for the grout which protects the prestressing steel.

H. Family of Systems: Group of post-tensioning tendon assemblies of various sizes which use common anchorage devices and design. All components within the family of systems shall be furnished by a single supplier and shall have a common design with varying sizes.

I. Fluidity: A measure of time, expressed in seconds necessary for a stated quantity of grout to pass through the orifice of a flow cone.

J. Grout: A mixture of cementitious materials and water with or without mineral additives or admixtures, proportioned to produce a pumpable consistency without segregation of the constituents, when injected into the duct to fill the space around the prestressing steel.

K. Grout Cap: A device that contains the grout and forms a protective cover sealing the post-tensioning steel at the anchorage.

L. Inlet: Tubing or duct used for injection of the grout into the duct.

M. Outlet: Tubing or duct to allow the escape of air, water, grout and bleed water from the duct.

N. Post-tensioning: A method of prestressing where tensioning of the tendons occurs after the concrete has reached a specified strength.

O. Prestressing Steel: The steel element of a post-tensioning tendon, which is elongated and anchored to provide the necessary permanent prestressing force.

P. Post-Tensioning Scheme or Layout: The pattern, size and locations of post-tensioning tendons provided on the Construction Drawings.

Q. Post-tensioning System: An assembly of specific models of hardware, including but not limited to anchorage assembly, local zone reinforcement, wedge plate, wedges, inlet, outlet, couplers, duct, duct connections and grout cap, used to construct a tendon of a particular size and type. The entire assembly must meet the system pressure testing requirement. Internal and external systems are considered independent of one another.

R. Pressure Rating: The estimated maximum pressure that water in a duct or in a duct component can exert continuously with a high degree of certainty that failure of the duct or duct component will not occur (commonly referred to as working pressure).

S. Set (Also Anchor Set or Wedge Set): Set is the total movement of a point on the strand just behind the anchoring wedges during load transfer from the jack to the permanent anchorages. Set movement is the sum of slippage of the wedges with respect to the anchorage head and the elastic deformation of the anchor components. For bars, set is the total movement of a point on the bar

just behind the anchor nut at transfer and is the sum of slippage of the bar and the elastic deformation of the anchorage components.

T. Strand: An assembly of several high strength steel wires wound together. Strands usually have six outer wires helically wound around a single straight wire of a similar diameter.

U. Tendon: A single or group of prestressing steel elements and their anchorage assemblies imparting prestress forces to a structural member or the ground. Also, included are ducts, grouting attachments, grout and corrosion protection filler materials or coatings.

V. Tendon Size: The number of individual strands of a certain strand diameter or the diameter of a bar.

W. Tendon Type: The relative location of the tendon to the concrete shape, internal or external.

X. Thixotropic: The property of a material that enables it to stiffen in a short time while at rest, but to acquire a lower viscosity when mechanically agitated.

Y. Wedge Plate: The hardware that holds the wedges of a multi-strand tendon and transfers the tendon force to the anchorage assembly. (Commonly referred to as anchor head)

Z. Wedge: A conically shaped device that anchors the strand in the wedge plate.

AA. Other words and terms used in these Specifications conform to the definitions given in ACI 301 and ACI 318.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Comply with requirements of ACI 301, Section 9 – Prestressed Concrete.

B. Store all materials in a weatherproof building, shed or container until time of use.

C. Labeling:

1. All components of a system shall be stamped with the suppliers name, trademark model number and size corresponding to catalog designation.
2. The shipping package must be clearly marked with a statement that the package contains high-strength prestressing steel, the care to be used in handling, and the type, kind and amount of corrosion inhibitor used, including the date when placed, safety orders and instructions for use. Specifically designate low relaxation (stabilized) strands per requirements of ASTM A416. Strands not so designated will be rejected.
3. Grout bags shall indicate application, date of manufacture, lot number and mixing instructions.

D. Protection of Grout:

1. Grouts shall be prepackaged in moisture proof containers.
2. Store grout in a dry location. Storage in the open shall be on a raised platform and with waterproof covering to protect the material.
3. Store grout on-site storage for no longer than one month.

E. Protection of Prestressing Steel.

1. Shipping, Handling and Storage: Protect all prestressing steel against physical damage and corrosion at all times, from manufacturer to final grouting or encasing in the concrete. Prestressing steel that has sustained physical damage shall be rejected. Carefully inspect any reel that is found to contain broken wires during use and remove and discard lengths of strand containing broken wires. The wire must be bright and uniformly colored, having no foreign matter or pitting on its surface.
2. Prestressing steel must be packaged in containers for protection of the steel against physical damage and corrosion during shipping and storage.
3. A corrosion inhibitor, which prevents rust, shall be placed in the package, or be incorporated in a corrosion inhibitor carrier type packaging material. The corrosion inhibitor shall have no deleterious effect on the steel or the concrete or bond strength of steel to concrete. Inhibitor carrier type packaging material shall conform to the provisions of MIL-PRF-3420. Immediately replace or restore packaging damaged from any cause, to the original condition.

F. During Installation in the Structure: The time between the first installation of the prestressing steel in the duct and the completion of the stressing and grouting operations shall not exceed seven calendar days Strands not so designated will be rejected. Any light surface corrosion forming during this period of time will not be cause for rejection of the prestressing steel.

G. Prestressing Steel: Ship, store, clean, and protect prestressing steel in accordance with Caltrans Standard Specifications Section 50, Prestressing.

H. Precast Pretensioned Members: Refer to Section 03 40 00, Precast Concrete.

I. Post-Tensioned Members: Precast pretensioned members may be handled immediately after transferring prestressing forces to concrete. Post-tensioned members may be handled three days after grout in hole or duct has set. For members with combination of both pretensioning and post-tensioning, the Contractor’s Engineer will determine time of handling. If stressing of prestressed members is not performed in a continuous operation, do not handle or disturb prestressed members until they are stressed to sustain all forces and bending moments due to handling.

J. Ducts: Furnish duct with end caps to seal the duct interior from contamination. Ship ducts in bundles that are capped and covered during shipping and storage. Protect ducts against ultraviolet degradation, crushing, excessive bending, dirt contamination, and corrosive elements during transportation, storage, and handling. Do not remove end caps supplied with the duct until the duct is incorporated into the bridge component. Store ducts in a location that is dry and protected from the sun. Storage shall be on a raised platform and completely covered to prevent contamination. If necessary, wash ducts before use to remove contamination.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Concrete: In accordance with Section 03 05 15, Portland Cement Concrete.

B. Prestressing Steel:

1. Strand: Grade 270, low relaxation 7-wire strand meeting the requirements of ASTM A416.

2. Bar: uncoated Grade 150, high strength, coarse thread bar meeting the requirements of ASTM A722, Type II.

C. Reinforcement: In accordance with Section 03 20 00, Concrete Reinforcing and tested in accordance with ASTM A370, Method A9.

2.2 POST-TENSIONING SYSTEMS

A. Post-tensioning systems consist of an assembly of components for various sizes of strand or bars assembled and pressure tested. Post-tensioning systems will have to be developed and tested both internal (corrugated duct) and external (smooth duct) applications for each of the following:

1. Standard tendon sizes for designing and detailing shall consist of 0.6 inch diameter strand in anchorages;
2. Standard bar sizes from 5/8 to 1- 3/4 inch diameter.
3. Systems using alternate anchorage sizes and/or strands utilizing 1/2 inch strand and providing equivalent force to these standard sizes may be submitted for approval.

B. Post-Tensioning System: Use approved post-tensioning systems of the size and type to construct tendons shown on the Construction Drawings. Substitution of components of approved post-tensioning systems is not permitted. For permanent applications, the use and location of bar couplers is subject to approval of the Contractor's engineer. Use only post-tensioning systems that utilize tendons fully encapsulated in anchorages and ducts. Systems which transfer prestress force by bonding the prestress steel strand directly to concrete are not permitted. Embedded anchors for bars are permitted. Systems utilizing formed, ungrouted voids or "Diablos" are not permitted. Strand or tendon couplers are not permitted.

2.3 GROUT

A. Grout: Select the post-tensioning grout for use by the proper application either repair, horizontal, or vertical. Grout will be mixed with potable water. Maintain grout fluidity in strict compliance with the grout manufacturer's recommendations and test with a flow cone.

1. Grouts: Materials with a total time from manufacture to usage in excess of six months shall be tested and certified by the supplier that the product meets the requirements of these specifications before use or the material shall be removed and replaced.
2. Chemical testing for fresh dry samples taken from a bag in each lot of pre-packaged group shall be performed to determine chloride concentrations in accordance with the following table under the Paragraph "Grout Physical Properties" in this Article.

B. Grout Physical Properties

1. Gas Generation: The grout shall not contain aluminum or other components which produce hydrogen, carbon dioxide or oxygen gas.
2. Laboratory Test: The grout shall meet or exceed the specified physical properties stated herein as determined by the following standard and modified ASTM test methods conducted at normal laboratory temperature (65-78°F) and conditions. Conduct all grout tests with grout mixed to produce the minimum time of efflux. Establish the water content to produce the minimum and maximum time of efflux. Refer to the following table:

Property Test	Value Test	Method
Total Chloride Ions	Max. 0.08% by weight of cementitious material	ASTM C1152
Fine Aggregate (if utilized)	99% passing the No. 50 Sieve (300 micron)	ASTM C136*
Hardened Height Change @ 24 hours and 28 days	0.0% to + 0.2%	ASTM C1090**
Expansion	≤ 2.0% for up to 3 hours	ASTM C940
Wet Density - Laboratory	Report maximum and minimum obtained test value lb/ft3	ASTM C185
Wet Density - Field	Report maximum and minimum obtained test value lb/ft3	ASTM C138
Compressive Strength 28 day (Average of 3 cubes)	≥7,000 psi	ASTM C942
Initial Set of Grout	Min. 3 hours Max. 12 hours	ASTM C53
Time of Efflux***		
(a) Immediately after mixing	Min. 20 Sec. Max. 30 Sec.	ASTM C939
	or Min. 9 Sec. Max. 20 Sec.	ASTM C939****
(b) 30 minutes after mixing with remixing for 30 sec	Max. 30 Sec.	ASTM C939
	Or Max. 30 Sec.	ASTM C939****
Bleeding @ 3 hours	Max. 0.0 percent	ASTM C940*****
Permeability @ 28 days	Max. 2,500 coulombs at 30 V for 6 hours	ASTM C1202

Table Notes:

* Use ASTM C117 procedure modified to use a #50 sieve. Determine the percent passing the #50 sieve after washing the sieve.

** Modify ASTM C1090 to include verification at both 24 hours and 28 days.

*** Adjustments to flow rates will be achieved by strict compliance with the manufacturer’s recommendations. The time of efflux is the time to fill a one liter container placed directly under the flow cone.

**** Modify the ASTM C939 test by filling the cone to the top instead of to the standard level.

***** Modify ASTM C940 to conform with the wick induced bleed test as follows:

Use a wick made of a 20 inch length of ASTM A416 seven wire 0.5 inch diameter strand. Wrap the strand with 2 inch wide duct or electrical tape at each end prior to cutting to avoid splaying of the wires when it is cut. Degrease (with acetone or hexane solvent) and wire brush to remove any surface rust on the strand before temperature conditioning.

Condition the dry ingredients, mixing water, prestressing strand and test apparatus overnight at 65 to 75°F.

Mix the conditioned dry ingredients with the conditioned mixing water and place 800 ml of the resulting grout into the 1,000 ml graduate cylinder. Measure and record the level of the top of the grout.

Completely insert the strand into the graduated cylinder. Center and fasten the strand so it remains essentially parallel to the vertical axis of the cylinder. Measure and record the level of the top of the grout.

Store the mixed grout at the temperature range listed above in (b).

Measure the level of the bleed water every 15 minutes for the first hour and hourly for two successive readings thereafter.

Calculate the bleed water, if any, at the end of the three hour test period and the resulting expansion per the procedures outlined in ASTM C940, with the quantity of bleed water expressed as a percent of the initial grout volume. Note if the bleed water remains above or below the top of the original grout height. Note if any bleed water is absorbed into the specimen during the test.

2.4 ANCHORAGES AND COUPLERS

A. Anchorages:

1. Ensure that anchorages develop at least 95 percent of the actual ultimate tensile strength of the prestressing steel when tested in an unbonded state, without exceeding the anticipated set.
2. Ensure that steel pipes used in the tendon anchorage zones are equipped with a shear transfer mechanism. Test and provide written certification that the shear transfer mechanism can resist at least 68 percent of the tendon's Guaranteed Ultimate Tensile Strength (GUTS) in a shear transfer pullout test described below:
    a. Shear Transfer Mechanism Pullout Test Procedure:
    b. Cast anchorage, shear transfer mechanism, and duct in a test block of concrete with minimum dimensions of 2 feet 6 inches x 2 feet 6 inches x required diaphragm length (6 feet minimum).
    c. Stress tendon to 80 percent of GUTS. Grout tendon.
    d. Transfer force from wedge plate to shear transfer mechanism. Alternate procedures may be used to safely obtain the required resistance force for the shear transfer mechanism.
    e. Measure tendon release force (must be greater than 68 percent of tendon's GUTS).
    f. Remove shim plates from behind anchor head and transfer tendon force through grout/shear transfer mechanism into test block.
    g. Record lowest transfer force measured over a sustained period of 1 hour.

3. Design anchorages so the average concrete bearing stress is in compliance with AASHTO
4. "Load and Resistance Factor Design (LRFD) Bridge Design Specifications".
5. Test and provide written certification that anchorages meet or exceed the testing requirements in the AASHTO "LRFD Bridge Construction Specifications".
6. Galvanize the embedded body of the anchorage in accordance with ASTM A123. Other components of the anchorage including wedges, wedge plate, and local zone reinforcement are not required to be galvanized. Construct the bearing surface and wedge plate from ferrous metal.
7. Equip all anchorages with a permanent grout cap vented and bolted to the anchorage. Provide wedge plates with centering lugs or shoulders to facilitate alignment with the bearing plate. Cast anchorages with grout outlets suitable for inspection from either the top or front of the anchorage. The grout outlet shall serve a dual function of grout outlet and post-grouting inspection access. The geometry of the grout outlets must facilitate being drilled using a 3/8-inch-diameter straight bit to facilitate endoscope inspection directly behind the anchor plate. Anchorages may be fabricated to facilitate both inspection

locations or may be two separate anchorages of the same type – each providing singular inspection entry locations.

8. Trumpets associated with anchorages shall be made of ferrous metal or polypropylene plastic material. The thickness of the duct at the transition location (choke point) shall not be less than the thickness of the duct, as established below. Alternately, the trumpet material may be polyolefin-containing antioxidant(s) with a minimum Oxidation Induction Time (OIT) according to ASTM D3895 of not less than 20 minutes. Perform OIT test on samples taken from the finished product. Test the remolded finished polyolefin material for stress crack resistance using ASTM F2136 at an applied stress of 348 psi, resulting in a minimum failure time of 3 hours.

B. Bar Couplers: Use couplers meeting the requirements of AASHTO “LRFD Bridge Design Specifications” and “LRFD Bridge Construction Specifications”. Test and provide written certification that couplers meet or exceed the testing requirements in the AASHTO “LRFD Bridge Construction Specifications”.

2.5 DUCTS AND PIPES

A. General:

1. Do not use ducts manufactured from recycled material.
2. Use seamless fabrication methods to manufacture ducts.
3. Ferrous metal ducts shall not be used.

B. Steel Pipes: Galvanized Schedule 40 steel pipes where indicated on the Construction Drawings in deviation blocks and diaphragms and other locations required by the Contractor’s engineer.

C. Corrugated Plastic Ducts: Use corrugated duct manufactured from non-colored unfilled polypropylene meeting the requirements of ASTM D4101 with a cell classification range of PP0340B14541 to PP0340B67884. The duct shall be white in color, shall contain antioxidant(s) with a minimum OIT according to ASTM D3895 of 20 minutes, and shall contain a non-yellowing light stabilizer. Do not use ducts manufactured from recycled material. Use seamless fabrication methods to manufacture ducts. Perform OIT test on samples from the finished product. Furnish duct with a minimum thickness, as defined in the following table:

Duct Shape	Duct Diameter	Duct Thickness
Flat	any size	0.08 inches
Round	0.9 inches	0.08 inches
Round	2.375 inches	0.08 inches
Round	3.0 inches	0.10 inches
Round	3.35 inches	0.10 inches
Round	4.0 inches	0.12 inches
Round	4.5 inches	0.14 inches
Round	5.125 inches	0.16 inches
Round	5.71 inches	0.16 inches

D. Smooth Plastic Ducts: Use smooth duct manufactured from 100-percent virgin polyethylene resin meeting the requirements of ASTM D3350 with a minimum cell class of 344464C. Use resin-containing antioxidant(s). Perform OIT test on samples taken from the finished product, resulting in a minimum OIT according to ASTM D3895 of 40 minutes. Manufacture duct with a dimension ratio (DR) of 17.0 or less, as established by either ASTM D3035 or ASTM F714 as

appropriate for the manufacturing process used. Use smooth duct meeting the minimum pressure rating (working pressure) of 100 psi and manufactured to either ASTM D3035 or ASTM F714.

2.6 DUCT AND PIPE ACCESSORIES

A. Inlets, Outlets, Valves and Plugs: Provide permanent grout inlets, outlets, and threaded plugs made of ASTM A240 Type 316 stainless steel, nylon, or polyolefin materials. For products made from nylon, the cell class of the nylon according to ASTM D5989 shall be S-PA0141 (weather-resistant), S-PA0231, or S-PA0401 (ultimate strength not less than 10,000 psi with UV stabilizer added). Products made from polyolefin shall contain antioxidant(s) with a minimum OIT according to ASTM D3895 of not less than 20 minutes. Perform OIT test on samples taken from the finished product. Test the remolded finished polyolefin material for stress crack resistance, using ASTM F2136 at an applied stress of 348 psi resulting in a minimum failure time of 3 hours. All inlets and outlets shall be equipped with pressure-rated mechanical shut-off valves or plugs. Inlets, outlets, valves, and plugs shall be rated for a minimum pressure rating of 150 psi. Use inlets and outlets with a minimum inside diameter of 3/4 inch for strand and 3/8 inch for single bar tendons and four-strand duct. Provide dual mechanical shutoff valves when performing vertical grouting. Specifically designate temporary items that are not part of the permanent structure on the post-tensioning (PT) system drawings. Temporary items shall be made of suitable materials.

B. Grout Caps: Use permanent grout caps made from approved polymer or ASTM A240 Type 316L stainless steel. The approved resins used in the polymer shall be either nylon, Acrylonitrite Butadiene Styrene (ABS), or polyester. For products made from nylon, the cell class of the nylon according to ASTM D5989 shall be S-PA0141 (weather-resistant), S-PA0231 or S-PA0401 (ultimate strength not less than 10,000 psi with UV stabilizer added). Seal the cap with O-ring seals or precision fitted flat gaskets placed against the bearing plate. Place grout vent on the top of the cap. Grout caps must be rated for a minimum pressure rating of 150 psi. Use ASTM A240 Type 316L stainless steel bolts to attach the cap to the anchorage. When stainless steel grout caps are supplied, provide certified test reports documenting the chemical analysis of the steel.

C. Duct Coupling and Connecting Devices:

1. Mechanical Couplers: Construct mechanical internal duct couplers with stainless steel, plastic, or a combination of these materials. Use plastic resins meeting the requirements of the following Paragraph entitled “O-Rings”, herein, to construct plastic couplers. Use ASTM A240 Type 316 stainless steel to make metallic components.
2. O-Rings: Provide O-ring duct coupling assemblies and segment seal mounting assemblies made from plastic resins meeting the requirements specified herein. Furnish standard O-ring material (diameter less than 0.25 inch) conforming to the following requirements:
    a. Mechanical Properties:
        1) Shore hardness, Shore A, ASTM D2240: 50-75
        2) Ultimate elongation percent, ASTM D412: 250 percent min.
        3) Tensile strength, ASTM D412: 1400 psi min.
    b. Accelerated Testing:
        1) Thermal deterioration: 70 hours at 257 degrees Fahrenheit, ASTM D573
        2) Change in tensile strength: ± 30 percent
        3) Change of elongation: -50 percent
        4) Change of hardness: ± 15 points
        5) Compression Set Method B, 22 hours at 257 degrees Fahrenheit, ASTM D395: 50 percent

6) Volume change due to absorption of $H2O$, Method D, for 70 hours at 212 degrees Fahrenheit, ASTM D471: + 10 percent

c. Environmental Resistance:

1) Ozone Resistance Exposure Method B, ASTM D1171: Pass
2) Low-temp non-brittle after three minutes at -40 degrees Fahrenheit, ASTM D2137: Pass

3. Furnish segment seal assemblies for large-diameter compression seals, used to couple ducts at segment joints, which conform to the requirements stated herein and with the following additions and changes:

a. Mechanical Properties:

1) Shore hardness, Shore A, ASTM D2240: 30-40
2) Tensile strength, ASTM D412: 600 psi min.
3) Compression Set Method B, 22 hours at 257 degrees Fahrenheit, ASTM D395: 60 percent

4. Heat Shrink Sleeves: Furnish heat shrink sleeves with unidirectional circumferential recovery manufactured specifically for the size of the duct being coupled, consisting of an irradiated and cross-linked high-density polyethylene backing for external applications and linear-density polyethylene for internal applications. Furnish adhesive with the same bond value to steel and polyolefin plastic materials. Ensure the heat shrink sleeves have an adhesive layer that withstands 150 degrees Fahrenheit operating temperature and meet the requirements of the following table:

Property	Test Method	Minimum Requirements	
		Internal Application	External Application
a) Minimum Fully Recovered Thickness	-	92 mils	111 mils
b) Peel Strength	ASTM D1000	29 pli	46 pli
c) Softening Point	ASTM E28	162 degrees Fahrenheit	216 degrees Fahrenheit
d) Lap Shear	DIN 30 672M	87 psi	58 psi
e) Tensile Strength	ASTM D638	2900 psi	3480 psi
f) Hardness	ASTM D2240	46 Shore D	52 Shore D
g) Water Absorption	ASTM D570	<0.05 percent	<0.05 percent

Color	**Test Method**	**Yellow**	**Black**
Minimum Recovery	Heat Recovery Test	33%	23%

2.7 SOURCE QUALITY CONTROL

A. Testing Requirements for Corrugated Plastic Duct: Ensure that the duct system components and accessories meet the requirements of Chapter 4, Articles 4.1 through 4.1.8 of FIB Bulletin 7, as modified herein. The requirements in FIB Bulletin 7 are modified as follows: Conduct the lateral load resistance test (FIB 4.1.4) without the use of a duct stiffener plate, using a load of 150

pounds for all sizes. Wear resistance of duct (FIB 4.1.7) must not be less than 0.06 inch for duct up to 3.35 inches in diameter and not less than 0.08 inch for duct greater than 3.35 inches in diameter. Bond length test (FIB 4.1.8) must achieve 40 percent GUTS in a maximum length of 16 duct diameters.

B. Minimum Bending Radius for Corrugated Plastic Duct: In addition to the component testing stated herein, the manufacturer shall establish, through testing, the minimum bending radius for the duct. Testing shall consist of a modified duct wear test, as described in Chapter 4, Article 4.1.7 of FIB Bulletin 7. The test apparatus shall be identical to the wear test apparatus, with the same clamping force as a function of the number of strands in the duct. However, modify the procedure as follows: Do not move the sample along the strand to simulate wear. The test duration shall be 7 days. Upon completion of the test duration, remove the duct. The minimum wall thickness along the strand path must not be less than 0.06 inch for duct up to 3.35 inches in diameter and not less than 0.08 inch for duct greater than 3.35 inches in diameter.

2.8 ACCESSORIES AND COATINGS

A. Formwork and Accessories: In accordance with Section 03 11 00, Concrete Forming.

B. Precast Prestressed Concrete Anchors, Lift Devices, and Accessories: Provide concrete inserts, reglets, anchors, fasteners, and lift devices as indicated or required for fabrication and installation work. All items shall be zinc-coated or galvanized in accordance with ASTM A153 or ASTM A123, as applicable. Select all anchors, fasteners, lift devices, and inserts, and shall be responsible for their performance and damage resulting from the use of faulty or inferior accessories. Lift devices shall not be visible on exposed faces of precast members.

C. Elastomeric Coatings: Use an elastomeric coating system to provide a waterproof barrier over post-tensioning anchorages and other areas designated in the Construction Drawings. Coating system components shall be supplied by a single manufacturer and sold as a waterproof coating system. The use of an epoxy prime coat is dependent upon the requirements of the manufacturer's waterproofing system. The polyurethane chemistry may be either waterborne aromatic (moisture-curing) or aromatic (moisture-sensitive). The minimum thickness of the system must not be less than 30 mils. The cured coating system must meet the following requirements:

Property	Test Method	External
Hardness, Shore A	ASTM D2240	60 to 90
Tensile Strength	ASTM D412	>750 psi
Elongation	ASTM D412	>400psi
Tear Strength	ASTM C957	>70 pli
Abrasion Resistance-	ASTM C957	<350 mg loss/1000 revs H-18 wheels 1000gm/wheel
Crack Bridging 1000 cycles	ASTM C957	System passes
Elongation Recovery	ASTM C957	>94 percent

PART 3 - EXECUTION

3.1 CONCRETE WORKS

A. Fabrication of Forms: In accordance with Section 03 11 00, Concrete Forming.

B. Manufacture precast, prestressed concrete units in accordance with PCI MNL-116, PCI MNL-117, PCI MNL 122, the “PCI Design Handbook,” and as specified herein. All tendons shall be bonded.

C. Place concrete for precast or cast-in-place unit In accordance with applicable requirements specified in Section 03 30 00, Cast-In-Place Concrete, and Section 03 05 15, Portland Cement Concrete.

1. Precautions: Use methods to place and consolidate concrete which will not displace or damage any of the post-tensioning ducts, anchorage assemblies, splices and connections, reinforcement or other embedments. Fabricate all duct splices to prevent duct kinks during concrete placement. Use mandrels as needed to maintain duct alignment and shape.
2. Proving of Post-Tensioning Ducts: Upon completion of concrete placement, prove that the post-tensioning ducts are free and clear of any obstructions or damage and are able to accept the intended post-tensioning tendons by passing a torpedo through the ducts. Use a torpedo having the same cross-sectional shape as the duct and that is a 1/4 inch smaller all around than the clear, nominal inside dimensions of the duct. Make no deductions to the torpedo section dimensions for tolerances allowed in the manufacture or fixing of the ducts. For straight ducts, use a torpedo at least 2 feet long. For curved ducts, determine the length so that when both ends touch the outermost wall of the duct, the torpedo is 1/4 inch clear of the innermost wall. If the torpedo will not travel completely through the duct, the reject the member, unless a workable repair can be made to clear the duct. The torpedo must pass through the duct easily, by hand, without resorting to excessive effort or mechanical assistance.
3. Problems and Remedies: The Reject ducts or any part of the work found to be deficient. Perform no remedial or repair work without the Contractor’s engineer’s approval.

D. Precast, prestressed concrete members: Steam cure under suitable enclosure that contains live steam and minimizes moisture and heat losses. Provide initial application of steam at 2 to 4 hours after final concrete placement. If retarders are used, increase waiting period before application of steam to 4 to 6 hours. Use steam at 100 percent relative humidity. Do not apply steam directly on concrete or on forms in a manner that would cause localized high temperatures. During application of steam, increase ambient air temperature within curing enclosure at rate not to exceed 40 degrees F per hour, until the maximum temperature between 140 to 160 degrees F is reached. Maintain this temperature until desired strength of concrete is attained. In discontinuing steaming, limit rate of decrease in ambient air temperature within curing enclosure to maximum of 40 degrees F per hour, until temperature of approximately 20 degrees F above air temperature to which concrete will be exposed to has been reached. Then, expose concrete. Keep exposed surfaces wet with fog spray, wet blankets, or other methods accepted by the Contractor’s engineer. Submit steam curing temperature charts. Water curing will be allowed in lieu of steam curing for prestressed members. Maintain water curing for at least 7 days after placing concrete. If required steam or water curing is completed and time lapses before prestress is applied to units under fabrication, keep units continuously wet until units are prestressed. Submit method of continued curing.

E. Finishes: Unless otherwise indicated, provide the following finishes as specified in Section 03 35 00, Concrete Finishing:

1. Formed Surfaces: Smooth form finish
2. Unformed Surfaces:
   a. Exposed to public view: Toweled finish

b. Concealed from public view: Floated finish

F. Markings: Provide permanent markings in precast, prestressed units to identify pickup points and orientation in the structure, complying with the markings indicated on the final shop drawings. Imprint the date of casting on each precast, prestressed unit where it will not show in the finished structure.

3.2 DUCT WORK

A. General: Use only plastic duct, steel pipe, or a combination of plastic duct and steel pipe. Ensure that all connectors, connections, and components of post-tensioning system hardware are airtight and watertight and pass the pressure test requirements herein. Use smooth plastic duct in all post-tensioning systems used for external tendons. Use corrugated plastic duct in all post-tensioning systems used for all internal tendons, except where steel pipe is required.

B. Installation:

1. General: Accurately and securely fasten all post-tensioning anchorages, ducts, inlet and outlet pipes, miscellaneous hardware, reinforcing bars, and other embedments at designated locations shown on the Construction Drawings, on the approved shop drawings, or as otherwise approved by the Contractor's engineer. Construct tendons using the minimum number of duct splices possible.
2. Ducts: Accurately align ducts and position at designated locations shown on the Construction Drawings, according to the approved shop drawings, or as otherwise approved by the Contractor's engineer. Securely fasten all internal ducts in position at regular intervals not exceeding 30 inches for steel pipes, 24 inches for round plastic duct, and 12 inches for flat ducts to prevent movement, displacement, or damage from concrete placement and consolidation operations. Show the method and spacing of duct supports on appropriate shop drawings. Ensure that ducts for external tendons are straight between connections to internal ducts at anchorages, diaphragms, and deviation saddles and supported at intermediate locations according to the Construction Drawings or approved shop drawings. Ensure that all alignments, including curves and straight portions, are smooth and continuous with no lips, kinks, or dents. This also applies to curves in pre-bent steel pipe. Carefully check and repair all ducts as necessary before placing concrete. After installing the ducts and until grouting is complete, ensure that all ends of ducts, connections to anchorages, splices, inlets, and outlets are sealed at all times. Provide an absolute seal of anchorage and duct termination locations by using plumber's plugs or equal. Grout inlets and outlets shall be installed with plugs or valves in the closed position. Leave low point outlets open. The use of duct tape is not permitted.
3. Splices and Joints: All splices, joints, couplings, connections (inlet and outlet), and valves shall be part of the approved post-tensioning system. Approved shrink sleeve material may be used to repair duct. The use of tape to repair or seal duct is not permitted.
4. Location of Grout Inlets and Outlets: Place grout inlets and outlets at locations shown on the Construction Drawings and shop drawings. Equip all grout inlets and outlets with positive shut-off devices. At a minimum, grout inlets and outlets shall be placed in the following positions:
   a. Top of tendon anchorage
   b. Top of grout cap
   c. At high points of the duct when vertical distance between the highest and lowest point is over 20 inches

   d. At a location 3 feet past high points of the duct on the downstream side opposite the direction of grouting
   e. At all low points
   f. At major changes in the cross-section of the duct
   g. At other locations required by the Contractor's engineer
   h. Extend grout tubes a sufficient distance out of the concrete member to allow for proper closing of the valves

5. Tolerances: Ensure the post-tensioning ducts in the final position are within the following tolerances:
   a. General: In general, tendons are not to be out of position by over ±1/4 inch in any direction without the Contractor's engineer's approval.
   b. Entrance and Exit Angles: Ensure that entrance and exit angles of tendon paths at anchorages and/or at faces of concrete are within ±3 degrees of the desired angle measured in any direction, and that deviations in the alignment are accomplished with smooth transitions without kinks.
   c. Angle Changes: Angle changes at duct joints shall not be greater than ±3 degrees in any direction and shall be accomplished with smooth transitions without kinks.
   d. Anchorages: Locate anchorages within ±1/4 inch of desired position laterally and ±1 inch along the tendon, except that minimum cover requirements shall be maintained.
   e. Anchorage Confinement Reinforcement: Position anchorage confinement reinforcement in the form of spirals, multiple U-shaped bars or links, to be centered around the duct and to start within 1/2 inch of the back of the main anchor plate.
   f. Conflicts: If conflicts exist between the reinforcement and post-tensioning duct, the position of the post-tensioning duct shall prevail and the reinforcement shall be adjusted locally with the Contractor's engineer's approval.

6. Duct and Pipe Minimum Diameter:
   a. For prestressing bars, provide duct with a minimum internal diameter of at least 1/2 inch larger than the outside diameter, measured across the deformations. For prestressing bars with couplers, size the duct to be 1/2 inch larger than the diameter of the bar and/or coupler.
   b. For multi-strand tendons, provide ducts with a minimum cross-sectional area 2-1/2 times the cross-sectional area of the prestressing steel.
   c. Connection Tolerance between Pipe and Duct: Steel pipe and plastic duct may be connected directly to each other when the outside diameters do not vary more than ±0.08 inch. Use a reducer when the diameters of the steel pipe and the plastic duct are outside of this tolerance.

7. Corrugated Duct Connections and Fittings: Make all splices, joints, joints between segments (segmental construction), couplings, and connections to anchorages with devices or methods (i.e., mechanical couplers, plastic sleeves in conjunction with shrink sleeve) that produce a smooth interior alignment with no lips or kinks. Design all connections and fittings to be airtight. Duct tape is not permitted to join or repair duct connections. Construct connections and fittings from polyolefin materials meeting the requirements specified in Article entitled "Duct and Pipe Accessories" under paragraph "Inlets, Outlets, Valves, and Plugs" herein. For post-tensioned systems intended for use with segmental constructed box girder bridges, the post-tensioning system shall include duct couplers at segment joints. Tendon duct couplers located at segment joints shall be mounted

perpendicular to the bulkhead and designed to receive a duct at an angle of 6 degrees deviation from perpendicular. The coupler shall be able to accommodate angular deviation of the duct without the tendon strands touching the duct or coupler on either side of the segment joint.

a. External Smooth Duct Connections: Use heat welding techniques to make splices between sections of plastic duct, in accordance with the duct manufacturer's instructions, or make connections with electrofusion coupler or other mechanical couplers meeting the material requirements of these Specifications. Ensure all connections have a minimum pressure rating (working pressure) of 100 psi, and produce a smooth interior alignment and a connection with no lips or kinks. Ensure all connections between steel pipe embedded in concrete and plastic duct are made by using a mechanical coupler or a circular sleeve made of Ethylene Propylene Deine Monomer (EPDM), with a minimum pressure rating (working pressure) of 100 psi. Use EPDM materials with 100-percent quality retention, as defined by ASTM D1171 "Ozone Chamber Exposure Method B". Use EPDM sleeves with a minimum wall thickness of 3/8 inch and reinforced with a minimum of four-ply polyester reinforcement. Use a 3/8-inch-wide power-seated band and clamps constructed from 316 stainless steel on each end of the boot, to seal against leakage of grout. Install the band with an 80 to 120-pound seating force.

b. Temporary Post-Tensioning Bar Ducts: Ducts for prestressing bars used exclusively for temporary post-tensioning are not required to be coupled across segment joints.

c. Duct Coupler O-Rings: The maximum force to compress the O-ring to its final compressed position shall not be greater than 25 psi times the area encircled by the O-ring. The seal shall be designed to accommodate the material flow within its own cross-sectional area by using a hollow or voided design. Assemblies holding the O-ring shall mount to the form bulkhead and provide for duct alignment.

d. Heat Shrink Sleeves: Install heat shrink sleeves using procedures and methods in accordance with the manufacturer's recommendations.

e. Proving of Post-Tensioning Ducts: Upon completion of concrete placement, prove that the post-tensioning ducts are free and clear of obstructions or damage and are able to accept the intended post-tensioning tendons by passing a torpedo through the ducts. Use a torpedo with the same cross-sectional shape as the duct and that is 1/4 inch smaller all around than the clear, nominal inside dimensions of the duct. Make no deductions to the torpedo section dimensions for tolerances allowed in the manufacture or fixing of the ducts. For straight ducts, use a torpedo at least 2 feet long. For curved ducts, determine the length so that when both ends touch the outermost wall of the duct, the torpedo is 1/4 inch clear of the innermost wall. If the torpedo does not travel completely through the duct, reject the member unless a workable repair can be made to clear the duct. The torpedo shall pass through the duct easily, by hand, without resorting to excessive effort or mechanical assistance.

3.3 JACKS

A. Tension prestressing steel by hydraulic jacks or other means acceptable to the Contractor's engineer. Equip each jack used to stress tendons with either pressure gauge or load cell, for determining jacking force. Submit accepted calibration chart for each jack. A qualified laboratory shall calibrate jack and gauge as one unit, with cylinder extension in approximate position so that jack will be at final jacking force in accordance with ASTM E4. If used, calibrate load cell and equip with indicator to determine prestressing force in tendon. Load cell range shall be such that lower 10 percent of manufacturer's rated capacity will not be used in determining jacking force.

1. Submit information as specified in ASTM E4 at least two weeks before using each jack. Limit variation of calibration curve to ±5 percent within loading range of jacking unit. Calibrate jacking equipment after each repair and at intervals not exceeding two years for load cell and one year for gauge and jack.
2. Recalibrate at any time accuracy of jacking unit is in doubt. Use pressure gauges with indicating dials at least 6 inches in diameter and accuracy in reading of 1 percent or better.
3. Use identical tensioning equipment on each end of the prestressed member when performing non-simultaneous post tensioning at both ends.
4. Seat anchorage cones with hydraulically operated pistons.
5. Take safety measures to prevent accidents due to possible breaking of prestressing steel or slipping of grips during tensioning process. Submit safety plans.

3.4 TENDONS

A. Stressing of Tendons: Prestressing shall be performed by methods and related equipment that is in conformance with accepted systems of prestressing in accordance with the Article entitled “Jacks” herein and comply with applicable requirements of ACI 318 and PCI MNL-116.

B. Pretensioning: Place prestressing steel Straighten wires, strands, wire groups, parallel-lay cables, and other prestressing elements to ensure proper positioning in enclosures for prestressed reinforcement. Use suitable horizontal and vertical bar supports or spacers to hold wires or strands in true position in enclosures. Do not use all-plastic bar supports or spacers.

1. Hold prestressing elements accurately in position while jacking. Keep record of jacking force and elongations produced. Several units may be cast in one continuous line and stressed at one time. Use of completed units in line as part of anchorage system will not be allowed. Leave sufficient space between ends of units to permit access for cutting after concrete has attained the required strength.

C. Transfer prestress by either multiple strand release method or by single strand release method.

1. When using multiple strand release method, release symmetrical group of strands or all strands gradually and simultaneously. Transfer strand load to jacking system, then gradually release jack(s) to relax strand loads.
2. When using single strand release method, release strands by slow-heat cutting, using low oxygen flame. Do not cut strands quickly. Following sequence of pattern and schedule of strand release, slowly heat each strand by moving low oxygen flame back and forth within a distance of 6 inches along strand, until necking down of strand wire occurs. Allow each strand to pull itself apart.
3. When member ends are not continuous, cut off exposed ends of prestressing steel not embedded in concrete, flush with member ends. Heavily coat cut-off exposed ends of prestressing steel with roofing asphalt or coal tar.
4. When member ends are continuous, extend prestressing steel embedded in concrete beyond member ends, as ordered by the Contractor’s engineer.

D. Post-Tensioning:

1. Do not apply post-tensioning forces until the concrete has attained the specified compressive strength as determined by cylinder tests. Conduct all stressing operations in the presence of the Contractor’s engineer.

2. Immediately after concreting, check ducts for obstructions by drawing cleaning device through them, by blowing through or moving tendon. Immediately prior to installation of tendons in ducts, demonstrate that ducts are free of water, debris, and other obstructions.
3. Tension prestressing steel Strands in each tendon, except for those in flat ducts with not more than four strands, shall be stressed simultaneously with a multi-strand jack. Unless otherwise indicated in the Construction Drawings, Construction Specifications, or shop drawings accepted by the Contractor's engineer, tendons in continuous post-tensioned members shall be tensioned by jacking at each end of tendon. For straight tendons and when one-end stressing is indicated in the contract documents, tensioning may be performed by jacking from one end or both ends of tendon, at the Contractor's option.
4. Conduct tensioning process to allow tension and elongation to be measured. Do not apply loads to concrete until strength specified for pretensioning method is attained. Apply loads no sooner than 10 days after last concrete placement. Stressing sequence shall be such that temporary, lateral eccentricity is minimized.
5. Friction: The Construction Drawings were prepared based on the assumed friction and wobble coefficients and anchor set noted on the Construction Drawings. Submit calculations and show a typical tendon force diagram (after friction, wobble and anchor set losses) on the shop drawings, based on the expected actual coefficients and values for the post-tensioning system to be used. Show these coefficients and values on the shop drawings. If, in the Authority's opinion, the actual friction significantly varies from the expected friction, revise post-tensioning operations so the final tendon force is in agreement with the Construction Drawings. When it is necessary to reduce friction, graphite may be used as a lubricant, subject to the Contractor's engineer's approval.
6. Wire Failures in Post-Tensioning Tendons: Multi-strand post-tensioning tendons having wires that fail by breaking or slippage during stressing may be accepted, provided the following conditions are met:
    a. The completed structure shall have a final post-tensioning force of at least 98 percent of the design total post-tensioning force.
    b. For precast or cast-in-place segmental construction and similar construction that has members post-tensioned across a common joint face at the stages of erection, the post-tensioning force across a mating joint shall be at least 98 percent of the post-tensioning required for that mating joint for that stage of erection.
    c. Single tendons shall have no more than 5-percent reduction in cross-sectional area of post-tensioning steel due to wire breakage.
    d. The above conditions may be waived with the Contractor's engineer's approval, when conditions permit the Contractor to propose acceptable alternative means of restoring the post-tensioning force lost due to wire failure.
    e. Except as noted on the Construction Drawings or the approved shop drawings, permanent post-tensioning tendons shall be stressed from both ends. The required force may be applied at one end and subsequently at the other end or simultaneously at both ends. Single end stressing is permitted when the following are satisfied:
        1) Space limitations prohibit double end stressing.
        2) The calculated elongation of the post-tensioning steel at the second end is 1/2 inch or less and wedges are power seated.
        3) Single end stressing applied at alternate ends of paired adjacent post-tensioning tendons is required to produce a symmetrical force distribution in agreement with the Construction Drawings or the approved shop drawings.

7. For construction in stages where some tendons are required to be stressed before others, install and stress in accordance with the Construction Drawings or approved shop drawings or as otherwise approved by the Contractor's engineer.

8. Cutting of Post-Tensioning Steel: Cut post-tensioning steel with an abrasive saw or plasma torch within 3/4 to 1-1/2 inches away from the anchoring device. Flame-cutting of post-tensioning steel is not allowed.
9. Tendon Protection: After stressing and before grouting internal or external tendons, install all grout caps, inlets, and outlets and test the tendons with compressed air to determine if duct connections require repair. In the presence of the Contractor's engineer, pressurize the tendons to 50 psi and lock off the outside air source. Record pressure loss for one minute. A pressure loss of 25 psi is acceptable for tendons that are 150 feet long or less, and a pressure loss of 15 psi is acceptable for tendons longer than 150 feet. If pressure loss exceeds the allowable amount, repair leaking connections using methods approved by the Contractor's engineer, and retest.

3.5 GROUTING

A. Grouting Operations Plan: Submit a Grouting Operations Plan for approval at least 6 weeks in advance of scheduled grouting operations. The Contractor's engineer's written approval of the Grouting Operations Plan is required before grouting of the permanent structure takes place. At a minimum, this plan shall address and provide procedures for the following items:

1. Names and proof of training for the grouting crew and the crew supervisor in conformance with these Specifications
2. Type, quantity, and brand of materials used in grouting including all certifications required
3. Type of equipment furnished, including capacity in relation to demand and working condition, as well as back-up equipment and spare parts
4. General grouting procedure
5. Duct pressure test and repair procedures
6. Method to be used to control the rate of flow within ducts
7. Theoretical grout volume calculations
8. Mixing and pumping procedures
9. Direction of grouting
10. Sequence of use of inlets and outlet pipes
11. Procedures for handling blockages
12. Procedures for possible post-grouting repair

B. Grout Inlets and Outlets: Ensure that connections from the grout pump hose to inlets are free of dirt and airtight. Inspect valves to ensure they can be opened and closed properly.

C. Supplies: Before grouting operations start, provide an adequate supply of water and compressed air for clearing and testing the ducts, and mixing and pumping the grout. Where water is not supplied through the public water supply system, a water storage tank of sufficient capacity shall be provided.

D. Equipment:

1. Provide grouting equipment consisting of measuring devices for water, a high-speed shear colloidal mixer, a storage hopper (holding reservoir), and a pump with all necessary connecting hoses, valves, and pressure gauge. Provide pumping equipment with sufficient capacity to ensure that the post-tensioning ducts to be grouted can be filled and vented without interruption, at the required rate of injection, in not more than 30 minutes. Provide an air compressor and hoses with sufficient output to perform required functions. Provide vacuum grouting equipment (volumetric measuring type) and experienced operators within 48 hours notice.

2. Mixer, Storage Hopper: Provide a high-speed shear colloidal mixer capable of continuous mechanical mixing, producing a homogeneous and stable grout free of lumps and undispersed cement. The colloidal grout machinery shall have a charging tank for blending and a holding tank. The blending tank shall be equipped with a high-shear colloidal mixer. The holding tank shall be kept agitated and at least partially full at all times during the pumping operation, to prevent air from being drawn into the post-tensioning duct. Add water during the initial mixing by use of a flow meter or calibrated water reservoir with a measuring accuracy equal to 1 percent of the total water volume.
3. Grout Pumping Equipment: Provide pumping equipment capable of continuous operation, including a system for circulating the grout when actual grouting is not in progress. The equipment shall be capable of maintaining pressure on completely grouted ducts, and shall be fitted with a valve that can be closed off without loss of pressure in the duct. Grout pumps shall be positive displacement type, provide a continuous flow of grout, and be able to maintain a discharge pressure of at least 145 psi. Pumps shall be constructed to have seals that adequately prevent oil, air, or other foreign substances from entering the grout and prevent loss of grout or water. The capacity shall be such that an optimal rate of grouting can be achieved. A pressure gauge with a full-scale reading of no more than 300 psi shall be placed at the duct inlet. If long hoses (in excess of 100 feet) are used, place two gauges – one at the pump and one at the inlet. The diameter and rated pressure capacity of the grout hoses shall be compatible with the pump output.
4. Vacuum Grouting Equipment: Provide vacuum grouting equipment consisting of the following:
   a. Volumeter for measurement of void volume
   b. Vacuum pump with minimum capacity of 10 cubic feet per minute (cfm), equipped with a flow meter capable of measuring the amount of injected grout.
   c. Manual colloidal mixers and/or dissolvers (manual high-speed shear mixers) for voids less than 5.28 gallons in volume.
   d. Standard colloidal mixers for voids 5.28 gallons and greater in volume.
   e. Stand-By Equipment: During grouting operations, provide a stand-by colloidal grout mixer and pump.

E. Grouting Procedures:

1. General: Perform test to confirm the accuracy of the volume-measuring component of the vacuum grouting equipment each day it is in use, before performing grouting operations. Use water or grout for testing, using standard testing devices with volumes of 0.5 and 6.5 gallons and an accuracy of equal to or less than 4 ounces. Perform one test with each device. The results shall verify the accuracy of the void volume-measuring component of the vacuum grouting equipment within 1 percent of the test device volume, and shall verify the accuracy of the grout volume component of the vacuum grouting equipment within 5 percent of the test device volume. Ensure the Contractor's engineer is present when tests are performed. Grout tendons in accordance with the procedures set forth in the approved Grouting Operations Plan. Grout all empty ducts.
2. Temperature Considerations: Maximum grout temperature shall not exceed 90 degrees Fahrenheit at the grout inlet. Use chilled water and/or pre-cooling of the bagged material to maintain mixed grout temperature below the maximum allowed temperature.
3. Mixing and Pumping: Mix the grout in accordance with the manufacturer's written instructions with a metered amount of water. Materials shall be mixed to produce a homogeneous grout. Continuously agitate the grout until grouting is complete.
4. Grout Production Test: During grouting operations, the fluidity of the grout shall be strictly maintained within the limits established by the grout manufacturer. A target fluidity rate

will be established by the manufacturer's representative based on ambient weather conditions. Determine grout fluidity by using either test method found in Article entitled "Grout" under "Physical Properties" "Laboratory Test". Perform fluidity test for each tendon to be grouted and maintain the correct water-to-cementitious ratio. Do not use grout that tests outside allowable flow rates. Prior to grouting empty ducts, condition grout materials as required to limit the grout temperature at the inlet end of the grout hose to 90 degrees Fahrenheit. Prior to performing repair grouting operations with vacuum grouting, condition grout materials to limit grout temperature at the inlet end of the grout hose to 85 degrees Fahrenheit. Check the temperature of the grout at the inlet end of the grout hose hourly. At the beginning of each day's grouting operation, perform a wick-induced bleed test in accordance with Article entitled "Grout" under "Physical Properties" "Laboratory Test". If zero bleed is not achieved at the end of the required time period, do not begin grouting of new or additional tendons until the grouting operations have been adjusted and further testing shows the grout meets the specified requirements.

5. Grout Operations: Open all grout outlets before starting the grouting operation. Grout tendons in accordance with the Grouting Operations Plan. Unless approved otherwise by the Contractor's engineer, pump grout at a rate of 16 to 50 feet of duct per minute. Conduct normal grouting operations at a pressure range of 10 to 50 psi measured at the grout inlet. Do not exceed the maximum pumping pressure of 145 psi at the grout inlet for round ducts and 75 psi for flat ducts in deck slabs. Use grout pumping methods that ensure complete filling of the ducts and complete encasement of the steel. Grout shall flow from the first and subsequent outlets until residual water or entrapped air has been removed prior to closing the outlet. Pump grout through the duct and continuously discharge it at the anchorage and grout cap outlets until all free water and air are discharged and the consistency of the grout is equivalent to that of the grout being pumped into the inlet. Close the anchorage outlet and discharge a minimum of 2 gallons of grout from the grout cap into a clean receptacle. Close the grout cap outlet. For each tendon, immediately after uncontaminated uniform discharge begins, perform a fluidity test using the flow cone on the grout discharged from the anchorage outlet. The measured grout efflux time shall not be less than the efflux time measured at the pump, or the minimum acceptable efflux time as established in Article entitled "Grout" under "Physical Properties" "Laboratory Test". Alternately, check the grout fluidity using the wet density method contained in Article entitled "Grout" under "Physical Properties" "Laboratory Test". The measured density shall fall within the values established in Article entitled "Grout" under "Physical Properties" "Laboratory Test". The density at the final outlet shall not be less than the grout density at the inlet. If the grout fluidity is not acceptable, discharge additional grout from the anchorage outlet and test the grout fluidity. Continue this cycle until an acceptable grout fluidity is achieved. Discard grout used for testing fluidity. After all outlets have been bled and sealed, elevate the grout pressure to ±75 psi, seal the inlet valve, and wait two minutes to determine if leaks exist. If leaks are present, fix the leaks using methods approved by the Contractor's engineer. Repeat the process above-stated herein until no leaks are present. If no leaks are present, bleed the pressure to 5 psi and wait a minimum of 10 minutes for entrapped air to flow to the high points. After the minimum 10-minute period has expired, increase the pressure as needed and discharge grout at each high point outlet to eliminate entrapped air or water. Complete the process by locking a pressure of 30 psi into the tendon. If the actual grouting pressure exceeds the maximum allowed, the inlet shall be closed and the grout shall be pumped at the next outlet, which has just been or is ready to be closed as long as a one-way flow is maintained. Grout shall not be pumped into a succeeding outlet from which grout has not yet flowed. If this procedure is used, the outlet/inlet to be used for pumping shall be fitted with a positive shutoff and pressure gauge. When complete grouting of the tendon cannot be achieved by

the steps stated herein, stop the grouting operation. After waiting 48 hours, fill the tendon with grout in accordance with the procedure outlined in Article entitled “Grouting” herein.

6. Vertical Grouting: Grouting of cable stays is not covered by these Specifications. For all vertical tendons, provide a standpipe at the upper end of the tendon to store bleed water and grout, and maintain the grout level above the level of the prestressing plate and anchorage. This device shall be designed and sized to maintain the level of the grout at an elevation that assures bleeding will at no time cause the level of the grout to drop below the highest point of the upper anchorage device. Design the standpipe to allow all bleed water to rise into the standpipe, not into the uppermost part of the tendon and anchorage device. Discharge grout and check grout fluidity as described in Article entitled “Grouting” herein. As grouting is completed, the standpipe shall be filled with grout to a level that assures that as settlement of the grout occurs, the level of the grout will not drop below the highest point in the upper anchorage device. If the level of the grout drops below the highest point in the anchorage device, immediately add grout to the standpipe. After the grout has hardened, the standpipe shall be removed. In the presence of the Contractor’s engineer, visually inspect for voids using an endoscope or probe. Fill all voids found in the duct using volumetric measuring vacuum grouting processes. For vertical tendons in excess of 100 feet or if the grouting pressure exceeds the maximum recommended pumping pressure, grout shall be pumped at increasingly higher outlets that have been or are ready to be closed as long as a one-way flow of grout is maintained. Grout shall be allowed to flow from each outlet until all air and water have been purged prior to using that outlet for pumping.
7. Construction Traffic and Operations Causing Vibrations: During grouting and for four hours upon completion of grouting, eliminate vibrations from all sources such as moving vehicles, jackhammers, compressors, generators, pile driving operations, and soil compaction that are operating within 300 feet down-station and 300 feet up-station of the ends of the span in which grouting is taking place.
8. Post-Grouting Operations and Inspection: Do not remove or open inlets and outlets until the grout has cured for 24 to 48 hours. Remove all outlets located at anchorages and high points along the tendon to facilitate inspection, and perform inspections within one hour after the removal of the inlet/outlet. Drill and inspect all high points along the tendon as well as the inlets or outlets located at the anchorages. Depending on the geometry of the grout inlets, drilling may be required to penetrate to the inner surface of the trumpet or duct. Use drilling equipment that automatically shuts off when steel is encountered. Unless grout caps are determined to have voids by sounding, do not drill into the cap. Perform inspections in the presence of the Contractor’s engineer using endoscopes or probes. Within four hours of completion of the inspections, fill all duct and anchorage voids using the volumetric measuring vacuum grouting process. Seal and repair all anchorage and inlet/outlet voids that are produced by drilling for inspection purposes. Remove the inlet/outlet to a minimum depth of 2 inches. Use an injection tube to extend to the bottom of the drilled holes for backfilling with epoxy. Post-grouting inspection of tendons with a length of less than 150 feet may utilize the following statistical frequency for inspection:
   a. For the first 20 tendons, inspect all outlets located at anchors and tendon high points by drilling and probing with an endoscope or probe. If one or more of the inspection locations are found to contain a defect (void), continue testing all tendons until 20 consecutive tendons have been inspected with no voids found.
   b. When no defects are detected as defined above herein, the frequency of inspection can be reduced to inspect every other tendon (50 percent). If a defect is located, inspect the last five tendons grouted. Return to the step above herein, and renew the cycle of 100-percent tendon inspection.

9. If tendon grouting operations were prematurely terminated prior to completely filling the tendon, drill into the duct and explore the voided areas with an endoscope. Probing is not allowed. Determine the location and extent of all voided areas. Install grout inlets as needed and fill the voids using volumetric measuring vacuum grouting equipment.
10. Grouting Report: Provide a Grouting Report signed by the Contractor and a representative of the entity performing the grouting within 72 hours of each grouting operation for Contractor’s engineer’s review. Report the theoretical quantity of grout anticipated, compared to the actual quantity of grout used to fill the duct. Notify the Contractor’s engineer immediately of shortages or overages. Report shall include the following information: Identification of the tendon; date grouted; number of days from tendon installation to grouting; type of grout; injection end and applied grouting pressure; ratio of actual to theoretical grout quantity; summary of problems encountered; and corrective action taken.

3.6 TOLERANCES

A. Tolerances: Fabricate prestressed concrete members to plan dimensions, within tolerances, in accordance with Product Dimension Tolerances, PCI MNL-116, Manual for Quality Control for Plants and Production of Precast and Prestressed Concrete Products. Actual acceptance or rejection of members having dimensions outside tolerance limits will depend on how the Contractor’s engineer believes those dimensional defects would affect structure's strength or appearance.

1. Modify and schedule fabrication of prestressed concrete members such that any increase in camber due to time, creep or other factors shall not cause total camber to exceed maximum camber immediately prior to erection of girders as indicated in the contract documents. Any prestressed concrete member that exceeds maximum camber specified in the Contract Documents will be rejected.

3.7 FIELD QUALITY CONTROL – SYSTEM TESTING

A. External Duct Systems: System testing for external duct requires two additional tests:

1. The anchorage and its connection to the duct/pipe assembly must be tested in accordance with and meet the requirements for internal duct systems (duct/pipe assembly consists of all components internal to the diaphragm concrete). Test the assembly at 1.5 psi.
2. The duct and pipe assembly consisting of all external duct connections (including welded duct splices and duct pipe) and a grout vent must comply with the following test: Condition the assembly by maintaining a pressure of 150 psi in the system for 3 hours. After conditioning, the assembly must sustain a 150-psi internal pressure for five minutes with no more than a 15-psi reduction in pressure. The length of the test pipe assembly for the second test is 15 feet.

B. Internal Duct Systems: Perform a system test of the assembly for compliance with the requirements of Chapter 4, Article 4.2, Stage 1 and Stage 2 Testing contained in FIB Bulletin 7 . For bar systems, modify the system test length to 15 feet. For systems being tested for use in precast segmental construction, modify this test to include one duct coupler (or O-ring assembly) to be used at the segment joint. Test the coupler for proper function by casting the coupler into a two-part concrete test block using match cast techniques. Use blocks that are at least 12 inches x 12 inches x 12 inches. After the concrete has hardened, pull the blocks apart and clean the surface of bond breaker materials. Using an external apparatus, clamp the blocks together and maintain 40-psi pressure on the block cross-section during the pressure test. Do not apply epoxy

between the blocks for this portion of the test. Pressurize the duct within the test block to 5 psi and lock off the outside air source. The assembly must sustain 5-psi internal pressure for five minutes with no more than a 0.5-psi reduction in pressure. Separate the duct coupler blocks from the duct system, remove the clamping device, and place a 1/16-inch layer of epoxy on the face of both blocks. Clamp the blocks together and maintain a pressure of 40 psi on the block cross-section for 24 hours. Upon removal of the clamping force, demolish the blocks. The coupler and attached ducts should be intact and free of epoxy and properly attached without crushing, tearing, or other signs of failure.

C. Internal Duct Pressure Test: Pressure test each different type and size of duct assembly at the site of casting before its first-time use on the Contract. Pressure test all assemblies used in a single component constructed for the first time on the Contract and thereafter, in groups of not more than 50 components. The Contractor’s engineer will randomly select one component for each group, but not less than a total of two for testing. Types of components include all post-tensioned components, including but not limited to transversely post-tensioned slabs, longitudinally post-tensioned girders, post-tensioned box girder segments, pier and bent caps, and columns. Longitudinal tendons in box segments are exempt from this testing. Test the assemblies in their final position just prior to concrete placement by sealing them at their anchorage or construction joint termini and then applying compressed air to determine if the assembly connections are pressure tight. In the presence of the Contractor’s engineer, pressurize the duct to 1.5 psi and lock off the outside air source, then record the pressure loss for one minute. If the pressure loss exceeds 0.15 psi, find and repair the leaks in the duct assembly using repair methods approved by the Contractor’s engineer and retest.

D. System Test Requirements: For each family of post-tensioning systems, assemble systems and perform the pressure test defined herein. For each family of post-tensioning systems, test two assemblies (largest and smallest) from the family. The post-tensioning assembly includes at least one of each component required to make a tendon from grout cap to grout cap. If applicable, include plastic duct to steel pipe connections and segment duct couplers.

1. Grouting Component Assembly Pressure Test: Assemble anchorage and grout cap with all required grouting attachments (including grout tube, valves, and plugs). Seal the opening in the anchorage where the duct connects. Condition the assembly by maintaining a pressure of 150 psi in the system for 3 hours. After conditioning, the assembly must sustain a 150-psi internal pressure for five minutes with no more than a 15-psi reduction in pressure. For systems using the same anchorages, grout caps and grouting attachments as a previously approved system. The Grouting Component Assembly Pressure Test may include documentation from a previous submittal, with written certification that the same components are being utilized in both anchorages.

3.8 FIELD QUALITY CONTROL

A. In accordance with General Conditions' requirements, the Contractor’s testing laboratory shall perform the following inspections and tests to establish the acceptability of the Work:

1. Placement of tendons and reinforcing steel
2. Stressing operations
3. Placement of grout and concrete

B. Sampling and Testing:

1. Concrete:
   a. Perform sampling, testing and frequency of testing in accordance with Section 03 30 00, Cast-In-Place Concrete, and Section 03 40 00, Precast Concrete, except as otherwise specified. Perform strength tests of concrete in accordance with the requirements specified in Section 03 05 15, Portland Cement Concrete, except as otherwise specified.
   b. Cylinder Test: In accordance with Section 03 05 15, Portland Cement Concrete.

2. Prestressing Steel:
   a. Perform testing requirements in accordance with ACI 301, Section 9 – Prestressed Concrete.
   b. Provide friction tests in accordance with Article entitled "Tendons" under Paragraph "Post-Tensioning" under "Friction".

3. Pipes and Ducts:
   a. Duct Pressure Field Test: After stressing and before grouting internal or external tendons, install all grout caps, inlets, and outlets and test the tendon with compressed air to determine if duct connections require repair. In the presence of the Contractor's engineer, pressurize the tendon to 50 psi and lock off the outside air source. Record pressure loss for one minute. A pressure loss of 25 psi is acceptable for tendons that are 150 feet long or less, and a pressure loss of 15 psi is acceptable for tendons longer than 150 feet. If the pressure loss exceeds the allowable, repair leaking connections using methods approved by the Contractor's engineer, and retest.

C. Record of Stressing Operations:

1. Keep a record of the following post-tensioning operations for each tendon installed:
   a. Project name
   b. Contractor and/or subcontractor
   c. Tendon location, size, and type
   d. Date tendon was first installed in ducts
   e. Reel number for strands and heat number for bars
   f. Tendon cross-sectional area
   g. Modulus of elasticity
   h. Date stressed
   i. Jack and gauge numbers per end of tendon
   j. Required jacking force
   k. Gauge pressures
   l. Elongations (theoretical and actual)
   m. Anchor sets (anticipated and actual)
   n. Stressing sequence (i.e., tendons to be stressed before and after)
   o. Stressing mode (one end/two ends/simultaneous)
   p. Witnesses to stressing operation (Contractor and inspector)
   q. Date grouted

2. Record other relevant information. Submit a complete copy of all stressing and grouting operations.

3.9 FORMING AND REPAIR OF HOLES AND BLOCKOUTS

A. Repair of Lifting and Access Holes: Repair all holes with epoxy grout meeting the requirements of Section 03 62 00, Non-Shrink Grouting. Immediately before making the repair (within 24 hours), mechanically clean and roughen the repair concrete surfaces to remove laitance and expose the small aggregate. Grit blasting or water blasting using a minimum 10,000 psi nozzle pressure is required. Flush surface with water and blow dry. Form, mix, place, and cure the material in strict compliance with the manufacturer's recommendations.

B. Repair of Grout Inlets and Outlets: Place threaded plastic caps in all required inlet/outlet locations required in the Construction Drawings. Repair inlets/outlets as shown on the Construction Drawings using epoxy grout meeting the requirements of Section 03 62 00, Non-Shrink Grouting. Prepare the surface to receive the epoxy in strict compliance with the manufacturer's recommendations.

3.10 PROTECTION OF POST-TENSIONING ANCHORAGES

A. General: Within 7 days upon completion of the grouting, protect the anchorage of post-tensioning bars and tendons as indicated in the Construction Drawings. The application of the elastomeric coating may be delayed up to 90 days after grouting. Use plastic or stainless steel threaded caps to plug all grout inlets/outlets. Use an epoxy grout meeting the requirements of Section 03 62 00, Non-Shrink Grouting, to construct all pour-backs located at anchorages.

   1. Protect other areas indicated to be protected on the Construction Drawings as specified herein for post-tensioning anchorages.

B. Preparation: Remove all laitance, grease, curing compounds, surface treatments, coatings, and oils by grit blasting or water blasting using a minimum 10,000 psi nozzle pressure. Flush surface with water and blow dry. Surfaces must be clean, sound, and without standing water. In case of dispute use ACI 503 for substrate testing and develop a minimum 175-psi tension (pull-off value).

C. Epoxy Grout Placing: Mix and apply epoxy in accordance with manufacturer's current standard technical guidelines. Construct all pour-backs in leak-proof forms creating neat lines. The epoxy grout may require pumping for proper installation. Construct forms to maintain a liquid head to ensure intimate contact with the concrete surface. Use vents as needed to provide for the escape of air, to ensure complete filling of the forms.

D. Elastomeric Coating Application: Surface preparation, mixing, and application of the coating system shall be applied in strict accordance with manufacturer's written requirements. Coat the exposed surfaces of all pour-backs and grout caps with elastomeric coating system, and with a thickness of 30 to 45 mils. Ensure concrete, grout caps, and other substrates are structurally sound, clean, and dry. Concrete shall be a minimum 28 days old. Remove all laitance, grease, curing compounds, surface treatments, coatings and oils by grit blasting or water blasting using a minimum 10,000-psi nozzle pressure to establish the anchor pattern. Blow the surface with compressed air to remove the dust or water. For elastomeric-coated pour-backs that will receive an architectural coating, apply a manufacturer's approved primer over the elastomeric coating before applying the architectural coating.

END OF SECTION

SECTION 03 11 00

CONCRETE FORMING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Layout of formwork.

B. Formwork construction.

C. Embedded items and openings in concrete.

D. Form release materials.

E. Removal of forms.

F. Field quality control.

G. Detection of movement.

H. Re-use of forms.

1.2 RELATED SECTIONS

A. Refer to Section 03 30 00, Cast-in-Place Concrete.

B. Coordinate formwork supported by falsework with the requirements of Section 03 11 14, Falsework.

C. Finishes for formed surfaces are specified in Section 03 35 00, Concrete Finishing.

1.3 REFERENCED STANDARDS

A. American Concrete Institute (ACI):

1. ACI 117 Specifications for Tolerances for Concrete Construction and Materials
2. ACI 301 Specifications for Structural Concrete
3. ACI 318 Building Code Requirements for Structural Concrete and Commentary
4. ACI 347 Guide to Formwork for Concrete

B. National Institute of Standards and Technology Voluntary Product Standard (VPS PS):

1. VPS PS 1 Structural Plywood

C. West Coast Lumber Inspection Bureau (WCLB):

1. WCLB No. 17 Standard Grading Rules

1.4 QUALITY ASSURANCE

A. Formwork Standards: Unless otherwise indicated, design, construct, erect, maintain, and remove forms and related structures for concrete work in accordance with applicable requirements of ACI 301, ACI 318, and ACI 347.

1. Architectural Concrete: Forms for architectural concrete shall be designed and constructed in accordance with ACI 301.
2. Deflection: Deflection shall be kept within the herein specified tolerances. At minimum where dead and live loads on forms will be more than 20 percent greater than the weight of the concrete, provide framing lumber of required strength, and comply with ACI 301 and ACI 347 for design of framing members.
3. Concrete Mix Design: Design of formwork shall be coordinated with the concrete mix design, as specified in Section 03 05 15, Portland Cement Concrete, so that form materials, form surfaces, and formwork strength will produce the desired concrete tolerances and finishes.

B. Formwork Surface Materials: Provide material and work quality, which will produce clean and uniform finished surfaces within the allowable tolerances specified and which will conform to the following requirements:

1. Concrete Exposed to View: Provide material and work quality that will produce clean, smooth, and uniform concrete surfaces. Refer to Section 03 35 00, Concrete Finishing, and ACI 301 for requirements.
2. Concrete Concealed from View: Provide material and work quality that will produce aligned concrete surfaces free of fins, honeycombs, and stains.

C. Special Formwork Sections: Provide openings, offsets, sinkages, keyways, recesses, moldings, rustication strips, chamfers, blocking, screeds, bulkheads, anchorages, embedded items, and other features. Select materials and provide workmanship that will ensure indicated finishes.

D. Chamfered Corners: All external corners shall be chamfered, unless otherwise indicated.

E. Removal Features: Design formwork to be readily removable without impact, shock, and damage to concrete surfaces and adjacent materials.

F. Tolerances for Formed Surfaces: For buildings and similar structures, comply with the requirements of ACI 301, as applicable. For those items of work or parts of the structure not covered by ACI 301, comply with the requirements of ACI 117, as applicable. Coordinate with the requirements specified in Section 03 30 00, Cast-In-Place Concrete.

1. The class of surface for offset between adjacent pieces of formwork facing material shall be Class A for surfaces permanently exposed to public view and Class C for surfaces that will be permanently concealed, unless otherwise specified.

G. Abrupt and Gradual Irregularities Tolerances for Formed Surfaces: In addition to the tolerance requirements of ACI 301, surfaces of buildings and similar structures permanently exposed to view shall conform to the abrupt and gradual irregularities tolerances specified herein. Abrupt irregularities shall be understood to mean offsets and fins resulting from displaced, mismatched, or misplaced forms, sheathing, or liners or from defects in forming materials. Gradual irregularities shall be understood to mean those resulting from warping and similar uniform

variations from planeness or true curvature. Gradual irregularities shall be checked with a straightedge for plane surfaces or a shaped template for curved or warped surfaces.

1. In measuring irregularities, the straightedge or template shall be placed in various places on the surface in various directions. Permitted abrupt or gradual irregularities in formed surfaces as measured within a 5-foot length with a straightedge shall be as follows:

Class of Surface	Maximum Abrupt or Gradual Irregularity
A	1/8 inch
B	1/4 inch
C	1/2 inch
D	1 inch

H. Shoring Calculations: Shoring drawings and calculations shall be signed by an engineer who is currently registered as a civil or structural engineer in the State of California.

1.5 SUBMITTALS

A. For formwork submittals involving falsework, comply with requirements specified in Section 03 11 14, Falsework.

B. Shop Drawings: Submit drawings that indicate and include the following details and requirements:

1. Forming system and method of erection with associated details.
2. Shoring drawings and design calculations. Include reshoring procedures.
3. Locations of construction joints in plan and elevation views. Means of leakage prevention for concrete exposed to view in finished construction.
4. Locations and sizes of conduits, openings, recesses, pipes, ducts, and other attached or embedded products.
5. Beam intersections and other conditions where concrete casting by vertical drop may be restricted.
6. Chamfer strips for corner treatment.
7. Method and schedule for removing forms and shoring.
8. Method for detecting formwork movement during concrete placement.

C. Product Data: Submit manufacturers' product data for manufactured products. Include products proposed for leakage control and for form release.

D. Samples: For textured or patterned form material, submit form material, 12 inches by 12 inches or larger in size, for formed concrete.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Storage: Store form panels to prevent warpage. Protect panels from damage and contamination, which could adversely affect concrete.

B. Handling: Lift form panels by methods that will protect panels from damage and distortion.

1.7 JOB CONDITIONS

A. Allow sufficient time between erection of forms and placing of concrete for the various trades to properly install concrete reinforcement, embedded items, sleeves, and blockouts.

B. Do not apply superimposed loads to the structure until concrete has developed its specified 28-day compressive strength.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Lumber: Boards and framing lumber shall be graded and grade-marked in accordance with WCLB No. 17. Provide framing lumber of required strength, conforming to the above-specified WCLB No. 17.

1. Boards: Provide all West Coast Species, "Construction" or "Standard" Boards. Use dressed side of lumber for surface in contact with the concrete, and provide boards with dressed or tongue-and-groove edges to provide tight joints to prevent mortar leakage.
2. Framing Lumber:
   a. Light Framing: Provide all West Coast Species, "Construction" or "Standard" Light Framing, dressed or rough. Where loads are not a factor, "Utility" Light Framing will be acceptable.
   b. Joists and Planks: Provide all West Coast Species, "No. 2" Structural Joists and Planks, dressed or rough.
   c. Beams and Stringers: Provide all West Coast Species, "Standard" Beams and Stringers or "No. 2 Structural" Beams and Stringers, dressed or rough.

B. Plywood: Plywood shall be graded and grade-marked in accordance with VPS PS 1. Plywood form panels for specific locations shall be as specified in the Construction Specifications, if applicable.

1. B-B Concrete Form Panels: Provide Class I, EXT.
2. B-C Concrete Form Panels: Provide Class I, EXT.
3. High Density Overlay (HDO) Concrete Form Board: Provide A-A, Class I, EXT.
4. Medium Density Overlay Concrete Form Board: Provide B-B or B-C, Class I, EXT.
5. Thickness: As required to maintain surface smoothness without deflection, but not thinner than 5/8 inch.

C. Steel Forms: Proprietary, patented, or fabricated steel forms, using standard or commercial quality, uncoated steel sheet or plate, 3/16-inch minimum thickness, for panel facings. Provide surfaces that will not impart corrosion residue to concrete. Include panel framing, reinforcement, and erection accessories.

D. Waffle Slab Forms: Steel or reinforced plastic dome forms for two-way joist construction, smooth surface, of sizes indicated.

E. Round Column Forms: Pressed or molded fiber-reinforced plastic or steel, manufactured round column forms, seamless or one-piece (one vertical seam), smooth surface, of sizes indicated.

1. Provide forms, which will not deflect under pressure of concrete placement and which will not deflect or blow off under added pressure of placement of fly-ash-modified concrete.

F. Form Liners for Exposed and Architectural Concrete: Thermally formed, pressed or molded fiber-reinforced plastic (FRP), ABS alloy plastic, PVC alloy plastic, or similar material, manufactured to produce finished concrete of design, configuration, and surface texture indicated. Form liners shall be continuous, one piece. No horizontal joints shall be acceptable unless the applicable height exceeds the available form liner height. Provide form liners with inherent form-release surface. Form liners may be manufactured for single-use or multi-use service as appropriate.

G. Leakage Control Materials: Provide materials capable of producing flush, watertight, and nonabsorbent surfaces and joints, and compatible with forming material and concrete ingredients. Seal form edges with gasketing material or sealant placed in the joint in such a way that neither a fin nor groove is made in the face of the cast concrete.

H. Form Release Agent: Commercial formulation, silicone-free form-release agent, designed for use on all types of forms, which will not bond with, stain, or adversely affect concrete surfaces, and which will not impair subsequent treatment of concrete surfaces requiring bond or adhesion or impede wetting of surfaces, which will be cured with water, steam, or curing compounds.

I. Plugged Cone Form Ties: Rod type, with ends or end fasteners which can be removed without spalling the concrete and which leave a hole equal in depth to the required reinforcement clearance. Form ties shall be of a design in which the hole left by the removed end or end fastener is easily filled to match the surface of the hardened concrete. Provide removable cones 1-1/4 inches in diameter by 1-1/2 inches deep. Provide preformed mortar plugs to match the color of the concrete, recessed 1/4 inch, adhered with an approved epoxy adhesive.

J. Inserts: Cast stainless steel or welded stainless steel, Type 316 or similar 300 Series, complete with anchors to concrete and fittings such as bolts, wedges, and straps. Provide hanger inserts spaced to match grid of suspended ceiling.

K. Dovetail Anchor Slots: 22 gage or heavier galvanized steel dovetail anchor slots, for anchoring of masonry veneer with galvanized steel dovetail anchors provided under Division 04, Masonry.

L. Chamfer Strips: 3/4-inch by 3/4-inch triangular fillets milled from clear, straight-grain pine, surfaced each side, or extruded vinyl type with or without nailing flange.

M. Miscellaneous Joint Strips: Preformed strips for reveals, rustications, and similar joints fabricated of wood, metal, or plastic.

N. Waterstops: Refer to Section 03 15 13, Waterstops, for requirements.

2.2 FABRICATION

A. Formwork - General: Fabricate forms in accordance with approved shop drawings. Maintain forms clean, smooth, and free from imperfections and distortion. Fabricate forms for architectural concrete in accordance with applicable requirements of ACI 301.

B. Joints:

1. Arrange form panels in symmetrical patterns conforming to general lines of the structure.
2. Unless otherwise indicated, orient panels on vertical surfaces with long dimension horizontal, and make horizontal joints level and continuous.
3. Align form panels on each side of the panel joint with fasteners common to both panels, and in a manner, which will result in a continuous, unbroken concrete plane surface.

C. Steel Forms: Use material, which is clean, smooth, and free from warps, bends, kinks, rust, cracks, and matter which may stain concrete. Fabricate panels in accordance with approved shop drawings. Deflection between form supports from concrete placement shall not exceed 1/240 of the span length.

PART 3 - EXECUTION

3.1 LAYOUT OF FORMWORK

A. Locate and stake out all forms and establish all lines, levels, and elevations.

3.2 CONSTRUCTION

A. Formwork:

1. Construct formwork in accordance with the approved shop drawings, and in a manner that will produce finished concrete surfaces conforming to indicated design and within specified tolerances. Formwork for concrete not exposed to view in the finished work may be constructed of any material that will adequately support the weight of the concrete.
2. Make joints and seams mortar-tight. Install leakage control materials in accordance with the manufacturer's installation instructions, and in a manner that will maintain a smooth continuity of plane between abutting form panels and which will resist displacement by concreting operations.
3. Kerf wood inserts for forming keyways, reglets, and recesses in a manner that will prevent swelling and ensure ease of removal.
4. Maintain forms clean and free from indentations and warpage. Do not use rust-stained steel surfaces for forms in contact with concrete. Do not sandblast steel form surfaces to remove rust or mill scale; remove these imperfections by grinding.
5. Brace temporary closures to prevent warpage or displacement and set tightly against forms in a manner that will prevent loss of concrete mortar.
6. Support joints with extra studs or girts, and in a manner that will ensure true, square intersections.
7. Assemble forms in a manner that will facilitate their removal without damage to the concrete.
8. Construct molding shapes, recesses, and projections with smooth finish materials and install in forms with sealed joints.
9. Provide camber in formwork as required to compensate for deflections caused by weight and pressures of fresh concrete and construction loads and as otherwise indicated. Provide camber strips to compensate for deflections due to permanent loads and long-term deflections due to shrinkage and creep as required.
10. Provide construction openings in forms where required for concrete pour pockets, vibrator access holes, and inspection openings to aid in proper placement and consolidation of concrete, and close up openings during placement of concrete as applicable.

11. Provide inspection and cleanout openings in forms at bottom of walls and columns and elsewhere as required. Do not close cleanouts until inspected and accepted in accordance with the Contractor's Quality Management Plan just before placing concrete.
12. Drill air escape holes in bottom members of blockouts.
13. Ensure that formed stair risers within a stair run are equal.

B. Edge Forms and Screeds for Slabs: Set edge forms or bulkheads and intermediate screeds for slabs to obtain required elevations and contours in the finished slab surface. Support screeds substantially without penetrating waterproofing membranes and vapor barriers.

C. Corner Treatment: Form chamfers with 3/4 inch on each leg, unless otherwise indicated, and accurately shape and surface in a manner, which will produce uniformly straight lines and edge joints and which will prevent mortar runs. Extend terminal edges to limits, and miter chamfer strips at changes in direction.

D. Construction Joints:

1. Locate joints as indicated. Support forms for joints in concrete so as to rigidly maintain their positions during placement, vibration, and curing of concrete. Install keys in all joints.
2. Locate and install construction joints, for which locations are not indicated, so as not to impair strength and appearance of the structure, and indicate such joints on shop drawings. Locations of construction joints require approval of the Contractor's engineer.
3. Position joints perpendicular to longitudinal axis of pier, beam, or slab as the case may be.
4. Locate joints in walls, vertically as indicated; at top of footing; at top of slabs on grade; at bottom of door openings; and at underside of the deepest beam or girder framing into wall; or as required to conform to indicated details.
5. Provide keyways as indicated in construction joints in walls and slabs, and between walls and footings unless otherwise indicated. Place construction joints perpendicular to the main reinforcement. Continue reinforcement across construction joints.

E. Load Supports: Loads for construction of roof slab and suspended floor slabs shall be carried down to on-grade base slabs. These loads shall not be carried by intermediate slabs at any time. Formwork loads shall be carried only by structural elements that are supported directly by footings.

3.3 EMBEDDED ITEMS AND OPENINGS IN CONCRETE

A. Install conduit, pipe sleeves, waterstops, appliance boxes, frames for items recessed in walls, door frames, drains, metal ties, inserts, nailing strips, blocking, grounds, and other fastening devices required for anchorage or attachment of other work. Firmly secure products in position, located accurately as indicated, before beginning concrete placement.

B. Provide openings in concrete for passage of ducts, and provide clearances therefor as indicated on approved shop drawings.

C. Where masonry walls will be tied to concrete construction in future construction, use dovetail anchor slots positioned for maximum flexibility for masonry installation.

3.4 FORM RELEASE MATERIAL

A. Coat form contact surfaces with approved form release material before reinforcement is placed. Do not allow excess form release material to accumulate in the forms or to come into contact with

surfaces that are required to be bonded to fresh concrete such as concrete reinforcement and embedded items. Apply form release material in compliance with manufacturer's application instructions.

B. Coat steel forms with non-staining, rust-preventive form release material or otherwise protect against rusting.

C. Apply form release material to bolts and rods that are to be removed or that are to be free to move.

3.5 REMOVAL OF FORMS

A. Remove forms by methods, which will not damage, mar, gouge, or chip concrete surfaces, overstress concrete members, or distort formwork. Use air pressure or other acceptable methods. Do not pry against concrete. Cut off nails flush. Leave surfaces clean and unblemished.

1. Where early form removal is not necessary and will not impact the Contractor's schedule, leave forms in place at least 72 hours, unless otherwise approved by the Contractor’s engineer.

B. When repair of surface defects or finishing is required at an early age, forms may be removed as soon as the concrete has hardened sufficiently to resist damage from removal operations and its own weight.

1. Concrete work that is damaged by removal operations shall be repaired as specified in Section 03 35 00, Concrete Finishing. Where exposed surfaces are damaged beyond acceptable repairing measures, the damaged concrete shall be removed and replaced with new concrete.

C. Top forms on sloping surfaces of concrete may be removed as soon as the concrete has attained sufficient stiffness to prevent sagging. Needed repairs or treatment required on such sloping surfaces shall be performed at once and shall be followed by the specified curing.

D. Wood forms for wall openings shall be loosened as soon as this can be accomplished without damage to the concrete.

E. Formwork for columns, walls, sides of beams, and other parts not supporting the weight of the concrete may be removed as soon as the concrete has hardened sufficiently so as not to be damaged by removal operations.

F. Forms and shoring in the formwork used to support the weight of concrete in beams, suspended slabs, girders, and other structural members shall remain in place until the concrete has reached adequate strength and stiffness to support itself. Forms shall not be removed before the concrete has reached a minimum of 70 percent of the indicated design compressive strength, unless otherwise approved in writing by the Contractor’s engineer.

G. When shores and other vertical supports are so arranged that the non-load-carrying form-facing material may be removed without loosening or disturbing the shores and supports, the facing material may be removed at an earlier age provided the concrete surfaces are not damaged by such earlier removal.

H. Plan reshoring operations in a manner that will ensure that areas of new construction will not be required to support their own weight. Reshoring shall be in place before shoring is removed. During reshoring, do not permit live loads on new construction. Do not locate reshores in a manner and location that will overstress members or induce tensile stresses where reinforcing bars have not been provided.

I. When removal of formwork or reshoring is based on the concrete reaching a specified strength, the concrete shall be presumed to have reached this strength when test cylinders, field cured along with the concrete they represent, have reached the strength specified for removal of formwork or reshoring. Except for the field curing and age at test, the cylinders shall be molded and tested as specified in Section 03 05 15, Portland Cement Concrete.

3.6 FIELD QUALITY CONTROL

A. Before placing concrete, check lines and grades of erected formwork and positioning of embedded inserts, blockouts, and joints for correctness. Verify that embedded piping and conduit are free from obstructions. Make corrections or adjustments to ensure proper size and location of concrete members and stability of forming systems.

B. While placing concrete, provide quality control to assure that formwork and related supports have not been displaced, that loss of cement paste through joints is prevented, and that completed work will be within specified tolerances.

C. During form removal, verify that architectural features meet the form and texture requirements of the approved samples.

3.7 DETECTION OF MOVEMENT

A. Check movement using methods, such as plumb lines, telltales, and survey equipment, to detect movement of formwork during concrete placement.

3.8 RE-USE OF FORMS

A. Clean and repair surfaces of forms to be reused in the work. Split, frayed, delaminated, or otherwise damaged form facing material will not be acceptable. Remove such material from the site. Apply form release coating as specified for new formwork.

B. Align and secure joints in a manner that will preclude offsets. Do not use patched forms for exposed concrete surfaces.

END OF SECTION

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SECTION 03 11 14

FALSEWORK

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Layout of falsework.

B. Falsework lighting.

C. Falsework construction.

D. Removal of falsework.

1.2 REFERENCE STANDARDS

A. ASTM International (ASTM):

1. ASTM A36/A36M Standard Specification for Carbon Structural Steel
2. ASTM A992/A992M Standard Specification for Structural Steel Shapes

B. California Code of Regulations, Title 8:

1. Chapter 4, Subchapter 4, Construction Safety Orders

C. State of California, Department of Transportation (Caltrans), Standard Specifications:

1. Section 12 Temporary Traffic Control
2. Section 48 Temporary Structures
3. Section 86 Electrical Systems

D. State of California, Department of Transportation (Caltrans), Office of Structure Construction:

1. Falsework Manual

E. West Coast Lumber Inspection Bureau (WCLB):

1. WCLB No. 17 Standard Grading Rules

1.3 SEQUENCING

A. Except for placement of foundation pads and piles, do not start construction of any unit of falsework until the shop drawings and calculations for that unit including falsework lighting plan have been reviewed and accepted.

1.4 SUBMITTALS

A. Shop Drawings and Calculations: Submit shop drawings and supporting calculations for falsework.

1. Submit drawings and design calculations for all falsework proposed for concrete structures requiring falsework support. Falsework design calculations shall include the stresses and deflections in load supporting members and shall be performed and sealed by an engineer who is currently registered as a civil or structural engineer in the State of California.
2. For structures other than concrete structures, where the height of any portion of the falsework, as measured from the ground line to the soffit of the superstructure, exceeds 14 feet, or where any individual falsework clear-span length exceeds 16 feet, or where provision for vehicular or pedestrian traffic through the falsework is made, such drawings shall be sealed and signed by an engineer who is currently registered as a civil or structural engineer in the State of California.
3. The drawings shall be accompanied by the Contractor's design calculations; and any other supplemental data required by the falsework design that is needed for a stress analysis.

B. Forming System: Furnish form design and materials data for each forming system to be used for exposed surfaces. Coordinate with the work of Section 03 11 00, Concrete Forming.

PART 2 - Falsework Lighting: Submit lighting plan showing details of falsework lighting, including pavement and portal lighting. PRODUCTS

2.1 MATERIALS

A. Requirements: Materials for falsework shall conform to applicable requirements of the Caltrans Standard Specifications, Section 48, Temporary Structures, and the Caltrans Falsework Manual, except as indicated or specified otherwise herein.

B. Lumber: All falsework lumber, posts, and timbers shall be graded and grade-marked in accordance with WCLB No. 17, dressed or rough. Provide stress-graded lumber for all falsework lumber, conforming to the above-specified WCLB No. 17.

C. Steel: ASTM A36/A36M, for M-, S-, C-, MC- and L-shapes as required. ASTM A992/A992M for W-shapes as required.

2.2 REGULATORY REQUIREMENTS

A. Regulatory Requirements: Falsework shall comply with applicable requirements of the California Code of Regulations, Title 8, Construction Safety Orders.

2.3 DESIGN CRITERIA

A. Design Standards:

1. In addition to the requirements specified herein, comply with the Caltrans Standard Specifications Section 48-2, "Falsework," and the Caltrans Falsework Manual.
2. All lumber, posts, and timbers shall be graded and grade-marked in accordance with WCLB No. 17. Provide stress-graded lumber for all structural members, conforming to the above-specified WCLB No. 17.

B. In addition to the Design Criteria specified herein, falsework over railroads that are open to traffic shall be designed and constructed in accordance with requirements of the jurisdictional authority.

C. Design Loads: Design loads for falsework shall conform to applicable requirements of Caltrans Standard Specifications, Section 48, Temporary Structures, and the Caltrans Falsework Manual.

D. Design Stresses, Loadings, and Deflections: The maximum allowable design stresses, loadings and deflections shall conform to applicable requirements of Caltrans Standard Specifications, Section 48, Temporary Structures, and the Caltrans Falsework Manual.

E. Falsework forms shall be designed to carry the load imposed upon them without exceeding the estimated soil bearing values and anticipated settlements.

F. When footing type foundations are proposed, determine the bearing value of the soil and show the values assumed in the design of the falsework on the falsework drawings.

G. When pile type foundations are proposed, show the maximum horizontal distance that the top of a falsework pile may be pulled out of position to support its cap. Also, show the maximum allowed deviation of the top of the pile, in its final position, from a vertical line through the point of fixity of the pile.

H. Show anticipated total settlements of falsework and forms. These shall include falsework footings settlement and joint take-up. Falsework supporting deck slabs and overhangs on girder bridges shall be designed so that there will be no differential settlement between the girders and the deck forms during placement of deck concrete.

I. Foundations for individual steel tower where the maximum leg load exceeds 30 kips shall be designed and constructed to provide uniform settlement under all legs of each tower under all loading conditions.

J. The support systems for form panels supporting concrete deck slabs and overhangs on girder bridges shall also be considered to be falsework, and shall be designed as such.

K. Temporary bracing shall be provided, as necessary, to withstand all imposed loads during erection, construction, and removal of falsework whose height exceeds its clear distance to either the edge of any sidewalk or shoulder of any roadway that is open to the public. The falsework drawings shall show provisions for such temporary bracing or methods to be used to conform to this requirement during each phase of erection and removal. Wind loads shall be included in the design of such bracing or methods.

L. Design of falsework shall be based on the use of loads and conditions that are no less severe than those specified in Article entitled “Design Criteria” herein, and on the use of stresses and deflections that are no greater than those specified in Article entitled “Design Criteria” herein. The Contractor shall be responsible for the proper evaluation of falsework materials and for the design of falsework to safely carry the actual loads imposed.

2.4 FALSEWORK LIGHTING DESIGN CRITERIA

A. Where vehicular or pedestrian traffic will pass through falsework, comply with the requirements specified in Caltrans Falsework Manual and Caltrans Standard Specifications Section 86-6.13, Falsework Lighting.

PART 3 - EXECUTION

3.1 LAYOUT

A. Locate and stake out all forms and falsework, and establish all lines, grades, and elevations.

3.2 CONSTRUCTION

A. Construct falsework to conform to the approved falsework shop drawings and applicable requirements of the Caltrans Standard Specifications, Section 48, Temporary Structures, and the Caltrans Falsework Manual.

B. Construct falsework lighting in accordance with the accepted lighting plan and the applicable requirements specified in Caltrans Standard Specifications Section 86-6.13 “Falsework Lighting”.

3.3 REMOVAL

A. Release and removal of falsework shall conform to applicable requirements of the Caltrans Standard Specifications, Section 48, Temporary Structures, and the Caltrans Falsework Manual.

END OF SECTION

SECTION 03 15 00

CONCRETE ACCESSORIES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Joint fillers.

B. Joint sealing compound.

C. Elastomeric joint seals.

D. Plastic pads, spacers, and fillers.

1.2 RELATED SECTIONS

A. Waterstops are specified in Section 03 15 13, Waterstops.

B. Elastomeric bearing pads are specified in Section 03 15 15, Elastomeric Bearing Pads.

C. Metal anchors, inserts, sleeves, and various metal accessories related to cast-in-place concrete work are specified in Section 05 50 00, Metal Fabrications.

D. Expansion and seismic control joints are specified in Division 07, Thermal and Moisture Protection.

1.3 REFERENCE STANDARDS

A. ASTM International (ASTM):

1.	ASTM C272	Standard Test Method for Water Absorption of Core Materials for Structural Sandwich Constructions
2.	ASTM C578	Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation
3.	ASTM C920	Standard Specification for Elastomeric Joint Sealant
4.	ASTM D994	Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type)
5.	ASTM D1621	Standard Test Method for Compressive Properties of Rigid Cellular Plastics
6.	ASTM D1622	Standard Test Method for Apparent Density of Rigid Cellular Plastics
7.	ASTM D1751	Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
8.	ASTM D2628	Standard Specification for Preformed Polychloroprene Elastomeric Joint Seals for Concrete Pavements
9.	ASTM D3405	Standard Specification for Joint Sealants, Hot-Applied, for Concrete and Asphalt Pavement

10.	ASTM D3406	Standard Specification for Joint Sealant, Hot-Applied, Elastomeric-Type, for Portland Cement Concrete Pavements
11.	ASTM D3542	Standard Specification for Preformed Polychloroprene Elastomeric Joint Seals for Bridges
12.	ASTM D6690	Standard Specification for Joint and Crack Sealants, Hot-Applied, for Concrete and Asphalt Pavements
13.	ASTM E84	Standard Test Method for Surface Burning Characteristics of Building Materials

1.4 SUBMITTALS

A. Shop Drawings: Submit drawings showing locations of all joints to be filled and sealed.

B. Product Data: Submit manufacturers' product data of joint fillers, sealing compounds, elastomeric joint seals, and plastic materials, verifying compliance with specified requirements.

C. Samples: Submit 12-inch long sample of joint filler and elastomeric joint seals and 1-pint can of sealing compound.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Joint Filler: Premolded, of sizes and thickness indicated, conforming to ASTM D994 or ASTM D1751, as applicable.

1. For structural joints and joints subject to movement, provide elastomeric joint seals conforming to ASTM D2628 or ASTM D3542, as applicable.

B. Joint Sealing Compound: Concrete joint sealant, conforming to ASTM C920 (Type S or M, Class 25, Use T), ASTM D6690, ASTM D3405, or ASTM D3406, as applicable, for sealing of expansion (isolation) and contraction (control) joints in slabs and at junctions of slabs and vertical surfaces. Color of joint sealant shall be as selected by the Contracting Officer from manufacturer's standards.

1. For asphalt pavements, provide ASTM D3405 sealant only. For concrete pavements and roadways, provide ASTM C920 or ASTM D3406 sealant.

C. Elastomeric Joint Seals: Preformed solid or multi-web design, virgin crystalization-resistant polychloroprene (neoprene) conforming to ASTM D2628 or ASTM D3542, as applicable. Seals shall be designed to function in a compressed installation mode.

1. Lubricant Adhesive: ASTM D2628 or ASTM D3542, as applicable.

D. Plastic Pads, Spacers, and Fillers: Extruded closed-cell polystyrene rigid board meeting requirements of ASTM C578, Type V, with the following physical properties:

1. Minimum weight and density when tested in accordance with ASTM D1622: 3.0 pounds per cubic foot.
2. Minimum compressive strength when tested in accordance with ASTM D1621: 100 pounds per square inch.

3. Maximum water absorption when tested in accordance with ASTM C272: 0.10 percent by volume.
4. Maximum allowable flame spread when tested in accordance with ASTM E84: 10 flame-spread index.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that joint surfaces are dry to the extent necessary for successful sealant application and long service life as recommended by the sealant manufacturer.

B. Verify that ambient and concrete-surface temperatures and humidity are within the ranges recommended by the manufacturer for successful sealant application.

3.2 PREPARATION

A. Thoroughly clean joints free of dirt, debris, dust, and laitance.

B. Prime joint surfaces, where required, as recommended by the manufacturer of the joint sealing compound or elastomeric joint seal, as applicable.

C. Mix multi-component sealing compound as recommended by the manufacturer.

3.3 INSTALLATION

A. Installation/Application Requirements: Joint fillers and sealing compounds shall be installed in accordance with the respective manufacturers' installation and application instructions. Comply also with ASTM D6690, ASTM D3405, Appendix XI., and ASTM D3406, Appendix XI., for application of sealants, as applicable. Coordinate the placement of joint fillers and securing them in position with the work of Section 03 11 00, Concrete Forming.

B. Expansion (Isolation) Joints:

1. Provide premolded joint filler to full depth of slabs, less 1/2 inch. Install joint filler with top edge 1/2 inch below the surface, and tool adjacent concrete edges to a 1/4-inch radius. Use steel pins to hold material in place during placing and floating of concrete. Finished joints shall be tight and leakproof.
2. After a minimum of 28 days and after slabs have been placed and finished, fill expansion joints with joint sealing compound to 1/8 inch below surface of slabs. No traffic shall be permitted to travel over sealed joints until sealing compound has properly cured.

C. Contraction (Control) Joints: Saw-cut contraction joints and weakened plane joints shall be filled with joint sealing compound in areas and locations indicated. Joints shall be filled and tooled flush to within 1/16 inch of the slab surface.

D. Roadway and Bridge: Provide elastomeric joint seals as applicable to the conditions. Install as indicated and in accordance with the manufacturer's installation instructions and recommendations.

E. Plastic Pads, Spacers, and Fillers: Install as indicated over or against clean surfaces. Apply adhesive where required to hold material in place.

END OF SECTION

SECTION 03 15 13

WATERSTOPS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Waterstops.

1.2 REFERENCE STANDARDS

A. U. S. Army Corp of Engineers, Concrete Research Division (CRD):

1. CRD-C513 Specifications for Rubber Waterstops
2. CRD-C572 Specifications for Polyvinylchloride Waterstops

1.3 SUBMITTALS

A. Shop Drawings: Submit drawings showing locations of all joints to receive waterstops and methods of supporting waterstops in forms without displacement from pressure of concrete placement.

B. Product Data: Submit manufacturers' product data of proposed waterstops for review.

C. Samples: Submit 12-inch long sample of typical waterstop and sample of field splice.

1.4 STORAGE AND HANDLING

A. Store waterstops in a manner that provides free circulation of air around the material.

B. Protect waterstop material from direct sunlight while in storage, and when only partially encased in concrete for over 48 hours.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Waterstops shall conform to CRD-C513 or CRD-C572, as applicable.

B. Material for rubber waterstops shall be natural rubber, suitable synthetic rubber, or a blend of natural and suitable synthetic rubber.

C. Material for PVC waterstops shall be an elastomeric plastic compound, the basic resin of which shall be polyvinyl chloride and containing any additional resins, plasticizers, or other materials needed for the material to comply with the requirements specified.

D. Waterstops shall be manufactured by such a process that produces a dense, homogenous product, which is free from holes and other imperfections. The cross section of the waterstop shall be uniform and symmetrical along its entire length.

E. Waterstops shall have the cross-sectional shape and dimensions indicated. Split-leg waterstops will not be permitted.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide waterstops for all construction joints in exterior walls, base slabs, suspended slabs, roof slabs, and other locations as indicated.

B. Install waterstops accurately in place and secure rigidly against movement by methods adequate to ensure proper support and embedment during the placement of concrete.

C. Unless otherwise indicated, install waterstops so that embedment in concrete will be equal on both sides of the joint.

D. Install waterstops in the longest practicable length, with joints spliced to form a continuous watertight seal for the full length of the joint.

E. Carefully place and consolidate concrete to ensure a complete filling and bond between the concrete and waterstop. A cement-sand grout slurry may be used where necessary to ensure contact and bond of waterstop and concrete without voids.

F. When installed in an expansion joint, locate waterstop so that the closed hollow center-bulb remains in the gap of the joint, to allow for maximum elongation with minimum stress on that portion of the waterstop embedded in the concrete. Install expansion joint material and a sealant in the joint, as indicated, to prevent foreign matter from accumulating in the joint area. When a sealant is used, place a separator (backer rod) between the sealant and the waterstop to assure that both the waterstop and sealant perform properly.

G. Repair or replace damaged, defective or misaligned waterstop material in accordance with the manufacturer's instructions.

3.2 SPLICING

A. PVC waterstops shall be butt-spliced by applying a thermostatically controlled electric source of heat and welding material in accordance with the manufacturer's splicing instructions. Rubber waterstops shall be butt-spliced by field vulcanizing. Lapped splices will not be permitted. Splices shall have a tensile strength not less than 60 percent of the unspliced materials' tensile strength. Maintain continuity of waterstop and bulbs.

3.3 FIELD QUALITY CONTROL

A. Waterstops and their joints shall be inspected for misalignment, bubbles, inadequate bond, porosity, cracks, offsets, and other defects that could reduce the effectiveness of joints against water penetration.

END OF SECTION

SECTION 03 15 15

ELASTOMERIC BEARING PADS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Plain elastomeric bearing pads.

B. Fabric-reinforced laminated bearing pads.

C. Steel-reinforced laminated bearing pads.

1.2 REFERENCE STANDARDS

A. ASTM International (ASTM):

1.	ASTM A36/A36M	Standard Specification for Carbon Structural Steel
2.	ASTM A1008	Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable
3.	ASTM A1011	Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength
4.	ASTM D395	Standard Test Methods for Rubber Property - Compression Set
5.	ASTM D412	Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension
6.	ASTM D429	Standard Test Methods for Rubber Property - Adhesion to Rigid Substrates
7.	ASTM D573	Standard Test Method for Rubber - Deterioration in an Air Oven
8.	ASTM D746	Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact
9.	ASTM D1043	Standard Test Method or Stiffness Properties of Plastics as a Function of Temperature by Means of a Torsion Test
10.	ASTM D1149	Standard Test Methods for Rubber Deterioration - Cracking in an Ozone Controlled Environment
11.	ASTM D2240	Standard Test Method for Rubber Property - Durometer Hardness
12.	ASTM D4014	Standard Specification for Plain and Steel-Laminated Elastomeric Bearings for Bridges

1.3 DEFINITIONS

A. As used in these Specifications, the word "elastomer" or "elastomeric" means "rubber"; the words are interchangeable.

1.4 SUBMITTALS

A. Product Data: Submit manufacturer's product data of elastomeric bearing pads for review. Include test data showing that the materials and fabricated pads meet the specified requirements.

B. Samples: Furnish sufficient quantity of elastomeric bearing pad to permit sampling of one unit for each type of pad used in the Work. Samples may be selected by the Contracting Officer at random from the lots delivered to the jobsite.

C. Certificates of Compliance: Submit certificates of compliance certifying that materials and fabrication of elastomeric bearing pads comply with these Specifications as applicable.

PART 2 - PRODUCTS

2.1 TYPES OF BEARING PADS

A. Plain Elastomer Type: Molded elastomeric compound, or cut from previously molded strips or slabs, or extruded and cut to length, with smooth surfaces and square edges.

B. Fabric-Reinforced Laminated Type: Laminated pads consisting of alternate layers of elastomeric compound and glass fabric reinforcement bonded together, with top and bottom layers of reinforcement uniformly covered with 1/8 inch of elastomer.

C. Steel-Reinforced Laminated Type: Laminated pads consisting of alternating steel laminates and internal elastomer laminates bonded together, with top and bottom layers of steel reinforcement uniformly covered with 1/4 inch of elastomer. Exposed sides shall be covered with 1/8 inch of elastomer.

2.2 MATERIALS

A. Elastomeric Compound/Elastomer: Virgin crystallization-resistant neoprene as the raw elastomer. Neoprene shall be the only polymer in the elastomeric compound and shall be not less than 60 percent by volume of the total compound. The elastomer shall comply with ASTM D4014, Type CR, Grade 3, with a shear modulus of 110 plus or minus 10 psi. Physical requirements of the elastomeric compound include the following:

1. Physical Properties:
   a. Hardness: ASTM D2240, Type D durometer, 60, plus or minus 6.
   b. Tensile Strength: ASTM D412, 2500 psi minimum.
   c. Ultimate Elongation: ASTM D412, 350 percent minimum.
   d. Instantaneous thermal stiffening at -40 degrees F: ASTM D1043, Not more than 4 times the stiffness measured at 73 degrees F.
   e. Low temperature brittleness at -40 degrees F: ASTM D746, Procedure B, Pass.

2. Heat Resistance: ASTM D573, 48 hours at 212 degrees F.
   a. Change in durometer hardness: plus 15 points maximum.
   b. Change in tensile strength: minus 15 percent maximum.
   c. Change in ultimate elongation: minus 40 percent maximum.

3. Compression Set: ASTM D395, Method B, 22 hours at 212 degrees F: 35 percent maximum.

4. Ozone Cracking: ASTM D1149, 100 pphm ozone in air by volume, 20 percent strain, 104 plus or minus 2 degrees F, 100 hours mounting procedure A in accordance with ASTM D1149: no cracks.
5. Adhesion: ASTM D429, Method B, bond made during vulcanization: 40 pounds per square inch.

B. Fabric Laminates: Fabric reinforcement shall be woven from 100 percent glass fibers of "E" type yarn with continuous fibers. Minimum thread count in either direction shall be 25 threads per inch. Fabric shall have either a crow-foot or an 8-Harness Satin weave. Each ply of fabric shall have a breaking strength of not less than 800 pounds per inch of width in each direction. Fabric reinforcement shall be single ply at top and bottom surfaces of the pad and double plies within the pad.

C. Steel Laminates: Steel for internal reinforcement laminates shall conform with the following requirements as indicated:

1. Steel 3/16-inch Thick and Over: Steel plate conforming to ASTM A36/A36M.
2. Steel Under 3/16-inch Thick: Steel sheet conforming to ASTM A1011/A1011M, Grade C or D, or ASTM A1008, Grade C or D.

D. Adhesive: Adhesive for the installation of bearing pads to concrete and steel bearing surfaces shall be a solvent-free adhesive as appropriate for this particular installation.

2.3 FABRICATION

A. For plain elastomeric bearing pads, pads 1/2 inch or less in thickness shall be either laminated or all elastomer. Pads over 1/2 inch in thickness shall be laminated. The stacking of individually laminated pads to attain thicknesses over 1/2 inch or the cold bonding of individual laminated pads is not allowed.

1. Elastomeric bearing pads may be cut from large sheets. Cutting shall be performed so as to avoid heating of the material, to produce smooth and square edges with no tears or other jagged areas, and to cause as little damage to the material as possible.

B. Laminated bearing pads shall be molded as a single unit under pressure and heat. Bonding of elastomer to reinforcement laminates shall be carried out during molding. Elastomer at outer edges of bonds to external load plates shall be shaped to avoid stress concentrations.

C. Steel-reinforced elastomeric bearing pads shall comply with the specifications for steel-laminated elastomeric bearings in ASTM D4014 and the following:

1. Bearing pads shall consist of alternating steel laminates and internal elastomer laminates with top, bottom, and side elastomer covers. Steel laminates shall have a nominal thickness of 0.075 inch (14 gage). Internal elastomer laminates shall have a thickness of 1/2 inch. Top and bottom elastomer covers shall each have a thickness of 1/4 inch. The combined thickness of internal elastomer laminates and top and bottom elastomer covers shall be equal to the bearing pad thickness shown. The elastomer cover to the steel laminates at the sides of the bearing shall be 1/8 inch. If guide pins or other devices are used to control the side cover over the steel laminates, any exposed portions of the steel laminates shall be sealed by vulcanized patching.
2. Total bearing thickness shall be equal to the sum of the thicknesses of the elastomeric laminates and covers and the steel laminates.

3. Internal steel laminates shall be free of sharp edges. Top and bottom steel laminates shall be covered uniformly with 1/4 inch of elastomer. Sides shall be covered uniformly with 1/8 inch of elastomer.

D. External load plates shall be protected from rusting.

E. Comply with ASTM D4014 for fabrication tolerances.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install elastomeric bearing pads at locations indicated in accordance with indicated details.

B. Apply adhesive to clean concrete bearing surface to a minimum thickness of 1/8 inch, and set bearing pads on adhesive bed as indicated.

END OF SECTION

SECTION 03 15 23

CONCRETE ANCHORS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Cast-in-place anchors.

B. Cementitious grouted anchors,

C. Post-installed (drilled-in) mechanical anchors.

D. Post-installed (drilled-in) adhesive anchors..

1.2 REFERENCE STANDARDS

A. American Association of State Highway and Transportation Officials (AASHTO)

1. AASHTO LRFD Bridge Design Specifications
2. AASHTO M314 Standard Specification for Steel Anchor Bolts

B. American Concrete Institute (ACI): Comply with the following ACI standards, as applicable:

1. ACI 318 Building Code Requirements for Structural Concrete and Commentary, Appendix D - Anchoring to Concrete
2. ACI 349 Code Requirements for Nuclear Safety Related Concrete Structures and Commentary, Appendix D - Anchoring to Concrete
3. ACI 349.2R Guide to the Concrete Capacity Design (CCD) Method - Embedment Design Examples
4. ACI 355.2 Qualification of Post-Installed Mechanical Anchors in Concrete and Commentary

C. American National Standards Institute (ANSI)

1. ANSI B212.15 Cutting Tools - Carbide-Tipped Masonry Drills and Blanks for Carbide-Tipped Masonry Drills.

D. American Railway Engineering and Maintenance-of-Way Association (AREMA)

1. AREMA Manual for Railway Engineering (MRE)

E. ASTM International (ASTM)

1. ASTM A153 Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
2. ASTM A615 Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
3. ASTM A706 Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement

4. ASTM B695 Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel
5. ASTM C824 Standard Practice for Specimen Preparation for Determination of Linear Thermal Expansion of Vitreous Glass Enamels and Glass Enamel Frits for the Dilatometer Method
6. ASTM C1107 Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)
7. ASTM E488 Standard Test Methods for Strength of Anchors in Concrete Elements
8. ASTM F593 Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs
9. ASTM F594 Standard Specification for Stainless Steel Nuts
10. ASTM F1554 Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength and Supplements S1, S4, and S5

F. International Code Council Evaluation Service (ICC-ES):

1. AC193 Acceptance Criteria for Mechanical Anchors in Concrete Elements
2. AC308 Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements

G. State of California, Department of Transportation (Caltrans) Standard Specifications:

1. Section 75-1.03 Miscellaneous Bridge Metal

1.3 REGULATORY REQUIREMENTS

A. In addition to the foregoing referenced standards, the regulatory requirements that govern the work of this Section include the following codes:

1. California Code of Regulations, Title 24, Part 2, California Building Code (CBC), Chapters 17 and 17A, “Structural Tests and Special Inspections”.

1.4 NOTED RESTRICTIONS

A. For bridge joints, only cast-in-place anchors shall be used in new concrete. Anchor bolts may be swedged or threaded. Expansion anchors, countersunk anchor bolts, and cement grouted anchor bolts shall not be used in new construction. Expansion (post-installed) anchors and countersunk anchor bolts may be used for bridge joints in accordance with AASHTO LRFD Article 14 .5.3.7 for existing facilities.

B. For highway and high speed train bridge bearings, only cast-in-place anchors shall be used in new concrete. Anchor bolts may be swedged or threaded. Expansion (post-installed) anchors, countersunk anchor bolts, and grouted in place anchor bolts may be used for bridge bearings in accordance with AASHTO LRFD Article 14.8.3.

C. For railroad bridge bearings, only cast-in-place or cementitious grouted anchors shall be used. Anchor bolts may be swedged or threaded. Expansion (post-installed) anchors and countersunk anchor bolts shall not be used for bridge bearings in accordance with AREMA MRE Chapter 14, Article 10.3.7.

D. For traffic signs, signals, and luminaires the requirements of Caltrans Standard Specification 75-1.03C shall be used. If permanent tension or vibratory loading is anticipated, adhesive anchors shall not be allowed.

E. The capacities of post-installed anchors shall be determined per independent testing laboratory in accordance with ACI 355.2 or ICC-ES AC193 for post-installed mechanical anchors, or ICC-ES AC308 for post-installed adhesive anchors. In no case shall manufacturer's literature be relied upon to determine capacities.

F. Post-installed, torque-controlled expansion anchors and undercut anchors where not otherwise prohibited by ICC-ES AC193 are permitted for use in fire-resistant rated construction provided they conform to ICC-ES AC193 Article 6.2.2.

G. Adhesive anchors shall not be used in overhead applications or connections where anchors must be capable of resisting sustained tension.

H. Adhesive anchors shall not be used where they will be exposed to sustained temperatures above 110-degrees Fahrenheit or short-term temperatures above 180-degrees Fahrenheit unless tested per ICC-ES AC308 for higher temperature.

I. Adhesive anchors shall not be installed if substrate temperature is below 40-degrees Fahrenheit unless tested per ICC-ES AC308 for lower installation temperature.

J. Cast-in-place anchors shall be used for seismic, vibration, fatigue, shock, or impact loadings, unless anchors are specifically tested in accordance with ASTM E488 for the loading to which they will be subjected. Cast-in-place anchors shall be used for blast loadings, unless anchors are specifically tested for the loading to which they will be subjected.

K. Post-installed anchors shall not be used with lightweight concrete unless specifically tested per ICC-ES AC193, ICC-ES AC308, or ACI 355.2

1.5 QUALITY CONTROL

A. Installer Qualifications: Post-installed anchors shall be installed by an installer with a minimum of five years experience performing similar installations.

B. Installer Training: Conduct thorough training with the manufacturer or the manufacturer's representative for the installer. Training shall consist of a review of the complete installation process for drilled-in anchors including the following:

1. Hole drilling procedure.
2. Hole preparation and cleaning technique.
3. Adhesive injection technique and dispenser training/maintenance.
4. Anchor element type, material, diameter, and length.
5. Proof loading/torquing.
6. Other procedures and techniques as necessary.

C. Certifications: Anchors shall have one of the following certifications:

1. ACI 355.2 Evaluation Report.
2. ICC-ES Evaluation Report indicating conformance with applicable ICC-ES AC193 or ICC-ES AC308.

1.6 SUBMITTALS

A. Product Data: Include recommended design values and physical characteristics for post-installed anchors including anchor embedment, test load and torque, and manufacturer's installation instructions.

B. Samples: Representative length and diameters of each type anchor shown on the Construction Drawings.

C. Test Reports: Certified test reports showing compliance with specified performance characteristics and physical properties.

1. Description of manner in which ASTM E488 vibration and fatigue loading testing has been tailored to simulate the type of load that the anchor will be subjected to during its use.

D. Installer Qualifications and Procedures: Submit installer qualifications as specified herein. Submit a letter of procedure stating method of drilling, the product proposed for use, the complete installation procedure, manufacturer's training date, and a list of the personnel to be trained on anchor installation.

E. Installation and Field Quality Control methods, including method of locating embedded reinforcing steel.

F. Certificates:

1. ACI Evaluation Reports.
2. ICC-ES Evaluation Reports.

G. Installation and testing methods.

H. Documentation:

1. Test Reports.
2. Installation Inspection Record
3. Test Inspection Record: The test inspection record shall include the following information:
   a. General location of anchor and group represented
   b. Method of test or verification
   c. Test results, accepted or rejected
   d. Inspector's name
   e. Date of test
   f. Identification number of testing tool
   g. Other information selected by the inspector or required in the Contractor's Quality Management System

4. Failed Anchor Documentation: Documentation for anchors is required for an anchor that does not pass the test acceptance criteria specified herein. Failed anchor documentation shall be submitted to the Contracting Officer. The documentation shall include the following:
   a. Exact location of failed anchor
   b. Reason for failure
   c. Repair steps taken
   d. Inspector's name

e. Date of test
f. Other information selected by the inspector or required in the Contractor's Quality Management System

I. Record Documents: Record Documents ("As-Builts") in respect to concrete anchors shall include, at minimum, product data, certificates, test reports, Installation Inspection Record, Test Inspection Record, and Failed Anchor Documentation.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle anchors in accordance with manufacturer's recommendations.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Fasteners and Anchors:

1. Bolts and Studs: ASTM F1554 AASHTO M314. Where bolts are designed for seismic, fatigue, vibration, shock, or impact, forces, Charpy V-Notch testing per ASTM F1554 S1, S4, and S5 shall be required.
2. Stainless Steel Bolts, Hex Cap Screws, and Studs: ASTM F593
3. Stainless Steel Nuts: ASTM F594
4. Zinc Coating: ASTM B695, Class 65
5. Hot-Dip Galvanizing: ASTM A153, Class C
6. Reinforcing Bars: ASTM A706, deformed Grade 60

2.2 CAST-IN-PLACE BOLTS

A. Bolts and studs, nuts, and washers shall conform to ASTM F1554, hot-dip galvanized including associated nuts and washers in accordance with ASTM A153. or Stainless steel anchor bolts, studs, nuts, and washers shall conform to ASTM F593 and ASTM F594.

B. Grout shall conform to ASTM C1107 with no shrinkage and tested in accordance with ASTM C824. Grout shall be non-metallic.

C. Sleeves shall be corrugated, galvanized steel or corrugated high-density polyethylene.

2.3 POST-INSTALLED ANCHORS

A. Anchors for exterior, damp, or aggressive` environment shall be Type 316 stainless steel.

B. Anchors for all other installations shall be hot-dip galvanized per ASTM A153 Class C or D, or mechanically coated per ASTM B695, Class 65.

C. Post-installed mechanical anchors shall conform to ACI 355.2 or ICC-ES AC193.

D. Post-installed adhesive anchors shall conform to ICC-ES AC308.

E. Post-installed adhesive anchors shall be tested for simulated seismic loads per ICC-ES AC308 and ASTM E488.

F. Post-installed adhesive anchors shall be tested for installation temperature below 40-degrees Fahrenheit. Anchors that are installed in concrete with temperatures below 40-degrees Fahrenheit shall be tested to the minimum allowable installation temperature per ICC-ES AC308.

G. Post-installed adhesive shall be tested for long-term temperature exposure of 110-degrees Fahrenheit in accordance with ICC-ES AC308. Anchors that are subject to higher temperatures shall be tested for the temperature that is equal to or exceeds the maximum long-term service temperature per ICC-ES AC308.

H. Post-installed adhesive anchors shall be tested for installation in holes drilled with any method or drill other than a carbide-tipped bit using a rotary hammer drill per ICC-ES AC308.

I. Post-installed adhesive anchors shall be tested for installation in water-saturated concrete per ICC-ES AC308.

J. Post-installed adhesive anchors shall be tested for standing water in holes per ICC-ES AC308.

K. Post-installed adhesive anchors shall be tested for use in submerged concrete per ICC-ES AC308.

L. Post-installed mechanical anchors shall be tested for installation in holes drilled with any method or drill other than a carbide-tipped bit using a rotary hammer drill.

M. Post-installed mechanical anchors shall be tested for simulated seismic loads per ACI 355.2. and ASTM E488.

N. Anchors shall be tested for vibration or fatigue loading in accordance with ASTM E488. Suitable testing provisions shall be included in the testing specifications to simulate the type of load that the anchor will be subjected to during its use.

2.4 DESIGN CRITERIA

A. Select applicable standards. Use AASHTO for highway work and AREMA for rail work.

B. Specific concrete anchor materials and products shall be as specified on the Construction Drawings or Construction Specifications.

PART 3 - EXECUTION

3.1 GENERAL

A. Training:

1. Installer Training: Implement a training and/or qualification program for installers of post-installed anchors. Anchor installers shall be trained and made fully familiar with the manufacturer’s installation procedures including additional requirements as specified or as directed.

B. Examination/Site Verification of Conditions:

1. The use of anchors shall be restricted to the applications and installations as indicated on the Construction Drawings.

2. Post-installed anchors may only be installed in sound concrete. Surfaces showing obvious distress by way of porosity, disintegration, carbonation, and cracks over 0.02-inch in width and 12-inches or longer and within the distance of the embedment length shall be reported to the Contractor's engineer for evaluation.

C. Preparation:

1. Existing reinforcement shall be exposed as indicated on the Construction Drawings to establish the reinforcement pattern before drilling.
2. No cutting of reinforcement will be permitted without prior written approval from the Contractor's engineer. Multi-cutting of the same bar is considered as one cut.
3. Reinforcement will be considered to be cut if:
    a. For No. 4 through No. 7: Cuts, nicks, or drill into bar body are greater than 1/16-inch
    b. For No. 8 and Larger: Cuts, nicks, or drill into bar body are greater than 1/8-inch

4. When installing anchors through cut reinforcement, the anchoring mechanism shall be located at least two anchor diameters beyond the cut reinforcement.

3.2 INSTALLATION

A. Cast-In-Place Anchors: Use templates to locate bolts accurately and securely in formwork.

B. Anchors shall be installed according to the location, spacing, and edge distances specified in the Construction Drawings.

C. Post-installed anchors shall be installed in accordance with the ICC-ES reports and manufacturer's installation instructions. Where installation criteria differ, the order of precedence from highest to lowest is 1) this Specification; 2) the ICC-ES reports; 3) the manufacturer's installation instructions.

D. Holes for post-installed anchors shall be drilled with carbide-tipped bits using rotary hammer drills meeting the requirements of ANSI B212.15 unless ICC-ES AC193 or ICC-ES AC308 testing demonstrates that using percussive drilling or another type(s) of bit, including core drills, is acceptable. Drilled holes shall be cleaned of chips, dust, loose material, and water prior to anchor installation. The hole diameters and depths shall be as recommended in the manufacturer's instructions. The hole diameter shall be checked every ten holes for conformance to the hole tolerances specified in ICC-ES AC308 for adhesive anchors, ICC-ES AC193 or ACI 335.2 for mechanical anchors. Verify depth of the concrete member before drilling holes. The embedment depth of the post-installed anchor shall not exceed the greater of 2/3 of the concrete member thickness or the concrete member thickness minus 1 1/2-inches. Contact the Contractor's engineer if these requirements cannot be met based on the actual member thickness.

E. Anchors shall be installed perpendicular to the concrete surface within a plus or minus 5-degree tolerance. Post-installation verification of this criterion may be satisfied by visual inspection to verify proper seating of the nut and washer.

F. In areas where concrete has been removed, the minimum anchor embedment shall be measured from the surface of sound concrete.

G. Unless otherwise noted on the Construction Drawings, the spacing requirements indicated in the applicable ICC ES report shall be used.

H. Bending and welding of post-installed anchors is not permitted.

I. The nut thread engagement for the anchors (studs) shall be such that the bolt threads project past the outside face of the nut when completely installed.

J. The length identification code on the head of the anchor shall not be damaged during installation. Anchor projection may be cut-off subject to the approval of the Contractor's engineer and documentation of the location, embedment, and length code.

K. Unused anchors shall be driven in and cut-off flush. Cut-off anchors shall be considered an abandoned ungrouted hole for future anchor spacing requirements.

L. Care shall be exercised to avoid bending anchors to match base plate holes, or loosening of anchors by prying sideways after tightening. Care shall also be exercised to ensure that the cone nut of an undercut anchors does not become loose from the stud during the setting or tensioning operation.

M. Non-grouted base plates may have a maximum 1/8-inch gap as evidenced under exterior edges around the plate provided that 1) the plate exhibits bearing contact within its interior against the concrete surface; and 2) the uneven bearing does not prevent application of the prescribed torque. If an unacceptable bearing contact condition exists, one of the following procedures shall apply:

1. The concrete surface shall be reworked to obtain a proper fit.
2. For gaps of up to 1-inch, the base plate may be grouted instead using the following technique:
   a. Insert post-installed anchors and set the base plate.
   b. Insert nuts to finger-tight condition.
   c. Install shims positioned no more than 1/2-inch away from the anchors to reduce gaps between base plate shims to 1/8-inch or less at anchor locations.
   d. Apply tightening torque. The bolt tightening shall not be performed when interior shims under the base plates have been placed away from anchors so that downward bending of the base plate would result upon tightening. Shims shall be moved as close as possible to the anchors before applying the installation torque.
   e. Fill the gap with non-shrink grout leaving the shims in place. For base plates on walls where grouting is not feasible, the gap may be filled with shim plates. The shims may be stacked but no more than four shims shall be stacked.

N. Relocating Holes Within Base Plates: The bolts may be relocated no more than 1-inch in any direction from the original position with respect to the attachment principal axis unless otherwise noted on the Construction Drawings.

3.3 INSPECTION

A. All anchors shall be visually inspected in order to verify and document that they have been installed as specified herein. As a minimum, inspection attributes for post-installed anchors shall comply with the special inspection section of the applicable ICC-ES report (with the exception of validating the strength of existing concrete) plus additional attributes imposed by this Specification. These attributes of inspection shall be identified in the inspection report documentation.

B. If visual inspection reveals that the installed anchor does not meet the specified requirements, the anchor shall be removed, replaced, or relocated with the written approval of the Contractor's engineer.

3.4 FIELD QUALITY CONTROL

A. An on-site Quality Control Program shall be provided for all post-installed adhesive anchors in accordance with ICC-ES AC308 Articles 14.3 and 14.4 and Annex A. Special inspection shall apply as spelled out in the referenced ICC-ES AC308 regardless of the applicability of the building code to a particular installation.

B. Full-time special inspection is required for all adhesive anchor systems together with proof load testing. Proof load testing alone is not recognized as meeting special inspection requirements.

C. When special inspections are required, make arrangements through the Contracting Officer with Authority-hired inspection agency and ensure that inspections and verifications are performed.

D. "Inspector" shall be understood to mean the special inspector.

E. Minimum anchor embedments, test (proof) loads, and torques shall be as shown on the approved shop drawings.

F. Testing of post-installed anchors shall be witnessed by the Inspector. Test of post-installed anchors is mandatory.

G. Testing Method: Post-installed anchors shall be tested by the direct tension method as follows:

1. Direct Tension Method: A tensile load as defined herein below is applied. If the tension load is applied by jacking against the concrete, the jacking pressure shall be distributed outside of an area having its center at the post-installed anchor and its diameter, or least dimension, equal to the required anchor spacing as given in the ICC ES report. Post-installed anchors tested by this method shall be retightened by applying the installation torques.
2. Testing shall be in accordance with ICC-ES AC308 Figure 5-1 or ACI 355.2 and ASTM E488.

H. Test (Proof) Load: Tension test (proof) load shall be as indicated on the approved shop drawings.

1. For post-installed adhesive anchors, the test shall be equal to the lesser of:
   a. A tensile load equal to 80-percent of the specified nominal yield strength of the anchor bolt material times the tensile area of the bolt; or
   b. A tensile load equal to twice the design load and at least 50-percent of the expected ultimate load based on the adhesive bond strength shown in the ICC-ES report, whichever is greater.

2. For post-installed mechanical anchors, the test load shall be a tensile load equal to 80-percent of the specified nominal yield strength of the anchor bolt material times the tensile area of the bolt.

I. Acceptance Criteria: A post-installed anchor is acceptable if the test load specified herein is attained without:

1. Slippage of more than:
   a. 1/16-inch for adhesive anchors.
   b. 2.5-percent of the embedded length, rounded to the nearest 1/16-inch for mechanical anchors.

2. Bolt failure.
3. A sign of damage in the surrounding concrete.

J. Test Frequency: Unless otherwise specified, the following test frequencies shall apply:

1. Post-Installed Mechanical Anchors: All anchors shall be tension-tested.
2. Post-Installed Adhesive Anchors: All anchors shall be tension-tested.

3.5 REPAIR AND RESTORATION OF DEFECTIVE WORK

A. Remove and replace misplaced or malfunctioning anchors. Fill empty anchor holes and patch failed anchor locations with high-strength non-shrink, nonmetallic grout. Anchors that fail to meet proof load or installation torque requirements shall be regarded as malfunctioning.

B. Abandoned holes shall be grouted with non-shrink grout. When post-installed anchors fail to meet the acceptance criteria under inspection and testing, the following repairs may be undertaken:

1. When failure is due to excessive anchorage pullout, the Contractor’s engineer shall evaluate the damage, develop a repair method, and document that method in writing. If approved, the anchor may be reset once prior to redrilling the hole and installing an anchor of equal size. Use the minimum spacing embedment depth, and installation torque required for the original anchor.
2. When failure is due to breaking of the anchor, slippage or loosening, bending, improper installation or poor attachment, remove the defective anchor, redrill the hole, and install the same diameter anchor if the integrity of surrounding concrete has not been disturbed.
3. For cases where excessive slippage upon torquing is experienced, or usage of the same hole is not possible, fill the existing hole with non-shrink grout and relocate the anchor location.
4. When failure is due to breakout of concrete around the anchor, the Contractor’s engineer shall evaluate the damage, develop a repair method, and document that method in writing. Local spalling of the concrete around the anchor, up to a maximum depth of 1/4-inch, is not considered a concrete breakout failure.
5. Mislocated anchors may be cut flush with concrete surface, and need not be removed if they do not interfere with subsequent installations.
6. Mislocated anchors or anchors installed for temporary applications may be left in place. Those anchors that must be removed to accommodate other attachments, aesthetics, or safety of personnel shall either be removed completely or abandoned in place by cutting off beneath the surface after chipping the concrete 1-inch minimum and patching with epoxy grout. Mislocated anchors that will be covered by a base plate or an attachment may be cut-off flush with the concrete. In the event that an anchor must be removed from the hole and a new anchor installed, the removal and installation of the new anchor shall be in accordance with the manufacturer’s specifications. The abandoned hole or removed concrete shall be filled with non-shrink grout.

7. Removal of installed anchors for inspection or replacement may be performed by using a bolt extractor as manufactured by Drillco Devices, Ltd., or approved equal.
8. Retest all replaced anchors as specified herein.

END OF SECTION

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SECTION 03 20 00

CONCRETE REINFORCING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Steel reinforcing bars.

B. Galvanized reinforcing bars.

C. Epoxy-coated reinforcing bars.

D. Wire and spiral reinforcement.

E. Welded steel wire fabric.

F. Steel bar mats.

G. Tie wire.

1.2 RELATED SECTIONS

A. Reinforcing steel for shotcrete is specified in Section 03 37 13, Shotcrete.

B. Reinforcing steel for prestressed concrete and precast concrete is specified in Section 03 05 18, Prestressed Concrete, and Section 03 40 00, Precast Concrete.

C. Reinforcing steel for piles, drilled shaft foundations, portland cement concrete paving, concrete curbs, gutters, and walks, and utility structures is specified in their respective Sections.

1.3 REFERENCED STANDARDS

A. American Concrete Institute (ACI):

1.	ACI 301	Specifications for Structural Concrete
2.	ACI 315	Details and Detailing of Concrete Reinforcement
3.	ACI 318	Building Code Requirements for Structural Concrete

B. ASTM International (ASTM):

1.	ASTM A82	Standard Specification for Steel Wire, Plain, for Concrete Reinforcement
2.	ASTM A184/A184M	Standard Specification for Deformed Steel Bar Mats for Concrete Reinforcement
3.	ASTM A185	Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete Reinforcement
4.	ASTM A370	Standard Test Methods and Definitions for Mechanical Testing of Steel Products

5.	ASTM A496	Standard Specification for Steel Wire, Deformed, for Concrete Reinforcement
6.	ASTM A497	Standard Specification for Steel Welded Wire Fabric, Deformed, for Concrete
7.	ASTM A706	Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
8.	ASTM A767/A767M	Standard Specification for Zinc-Coated (Galvanized) Steel Bars For Concrete Reinforcement
9.	ASTM A775/A775M	Standard Specification for Epoxy-Coated Reinforcing Bars
10.	ASTM A775/A775M	Standard Specification for Epoxy-Coated Steel Reinforcing Bars
11.	ASTM A884/A884M	Standard Specification for Epoxy-Coated Steel Wire and Welded Wire Fabric for Reinforcement
12.	ASTM D3963/ D3963M	Standard Specification for Fabrication and Jobsite Handling of Epoxy-Coated Steel Reinforcing Bars
13.	ASTM D3963/D3963M	Standard Specification for Fabrication and Jobsite Handling of Epoxy-Coated Steel Reinforcing Bars
14.	ASTM E8	Standard Test Methods of Tension Testing of Metallic Materials
15.	ASTM E165	Standard Practice for Liquid Penetrant Examination for General Industry

C. American Welding Society (AWS):

1.	AWS D1.4/D1.4M	Structural Welding Code - Reinforcing Steel

D. Concrete Reinforcing Steel Institute (CRSI):

1. CRSI Manual of Standard Practice
2. CRSI Placing Reinforcing Bars

E. State of California, Department of Transportation (Caltrans), Standard Specifications:

1.	Section 52	Reinforcement

1.4 SUBMITTALS

A. Shop Drawings:

1. Submit bar lists, bending diagrams and schedules, and placement plans and details for all reinforcing steel. Bar lists shall include weights.
2. Indicate descriptions, details, dimensions, arrangements and assemblies, and locations of reinforcing steel. Include number of pieces, sizes, and markings of reinforcing steel, laps and splices, supporting devices and accessories, and any other information required for fabrication and placement. Indicate adjustments required as specified in Article entitled “Quality Assurance” herein.
3. Coordinate with Construction Drawings for anchor bolt schedules and locations, anchors, hangers, inserts, conduits, sleeves, blockouts, and any other items to be cast in concrete for possible interference with reinforcing steel. Indicate required clearances on shop drawings.
4. Detail reinforcing steel in accordance with requirements of the ACI 315. Indicate individual weight of each bar, total weight of each bar size, and total weight of all bars on the list. Base calculated weights upon nominal weights specified in ACI 318, Appendix on Steel Reinforcement Information.

B. Product Data:

1. Submit manufacturers' product data and installation instructions for proprietary manufactured materials and reinforcement accessories.
2. Submit manufacturers' product data and installation instructions for proprietary exothermic metal splicing systems and proprietary mechanical coupler splicing systems when such splicing methods are permitted.

C. Certificates:

1. For each lot or load of reinforcing steel delivered to the jobsite, furnish mill affidavits or test reports of compliance or similar certification, certifying the grades and physical and chemical properties of the reinforcing steel and conformance with applicable ASTM Specifications, including ASTM A370, Method A9.
2. For galvanized and epoxy-coated reinforcing bars, furnish certificates of compliance with ASTM A767/A767M for galvanized bars and with ASTM A775/A775M and D3963/D3963M for epoxy-coated bars.
3. For welders, furnish welding certificates or affidavits attesting to the welders' qualifications to perform the indicated welding in accordance with applicable requirements of AWS D1.4.
4. For exothermic sleeve coupler splicing, furnish certificates or affidavits attesting to the crew's special qualifications to perform the splicing.

1.5 QUALITY ASSURANCE

A. Adjustments: Bars may be moved as necessary to avoid interference with other reinforcing steel, conduits, or embedded items. If bars are moved more than one bar diameter, or in excess of the above tolerances, the resulting arrangement of bars shall require the Contractor engineer's approval. Minimum spacings shall not be decreased, and the required number of bars shall be placed. Bars moved to permit access for cleanup operations shall be properly replaced and secured before the start of concrete placement.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver reinforcing bars to the fabricator in bundles, limited to one size and length of bar, securely tied and identified with plastic tags in an exposed position indicating the mill, the melt or heat number, and the grade and size of bars.

B. Deliver steel reinforcement to the jobsite, store, and cover in a manner, which will ensure that no damage will occur to it from moisture, dirt, grease, oil, or other cause, which might impair bond with concrete.

C. Deliver steel reinforcement to the jobsite properly tagged and identified, as specified herein in Article entitled “Identification”, in accordance with approved shop drawings.

D. Handle and store galvanized and epoxy-coated reinforcement in a manner, which will prevent damage to the coatings. For epoxy-coated reinforcement, comply with the requirements of ASTM D3963/D3963M.

E. Maintain identification of steel reinforcement after bundles are broken.

F. Provide special facilities for the storage and handling of exothermic materials as recommended by the splicing system manufacturer.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Steel Reinforcing Bars:

1. Low-Alloy Steel Bars: ASTM A706.
2. Weights of Bars: Refer to ACI 318, Appendix on Steel Reinforcement Information.

B. Galvanized Reinforcing Bars: ASTM A706, galvanized in accordance with ASTM A767/A767M, Class I coating. Bars shall be cut and bent cold before galvanizing.

C. Epoxy-coated Reinforcing Bars: ASTM A706, epoxy-coated in accordance with ASTM A775/A775M and ASTM D3963/D3963M. Coating material shall conform to ASTM A775/A775M and ASTM D3963/D3963M, Annex A1, green in color. Furnish acceptance test reports for each lot of epoxy-coated bars delivered to the site. Bars shall be cut and bent cold before applying coating material.

D. Wire and Spiral Reinforcement: ASTM A82 for plain wire and ASTM A496 for deformed wire.

E. Welded Steel Wire Fabric - Plain Wire: ASTM A185, wire sizes and center-to-center spacings as indicated.

F. Welded Steel Wire Fabric - Deformed Wire: ASTM A497, wire sizes and center-to-center spacings as indicated.

G. Welded Steel Wire Fabric - Epoxy-Coated: ASTM A884/A884M, wire sizes and center-to-center spacings as indicated.

H. Steel Bar Mats - Deformed Bars: ASTM A184/A184M, using ASTM A706 deformed bars, sizes and spacings of members as indicated, welded or clipped at intersections.

I. Accessories: Provide reinforcement accessories, consisting of bar supports, spacers, hangers, chairs, ties, and similar items as required for spacing, assembling, and supporting reinforcement in place. Conform with CRSI referenced standards and the following requirements:

1. For footings, grade beams, and slabs on grade, provide supports with precast concrete or mortar bases or plates or horizontal runners where wetted base materials will not support chair legs.
2. For exposed-to-view concrete surfaces, where legs of supports are in contact with forms or are in close proximity to finish surfaces, provide supports with legs which are galvanized, plastic-protected, or stainless steel.
3. For galvanized reinforcement, provide all galvanized accessories.
4. For epoxy-coated reinforcement, provide accessories, which are nylon-, epoxy, or plastic-coated.

J. Tie Wire: No. 16 gage or heavier, black or galvanized, soft or commercial grade steel tie wire. For galvanized reinforcement, provide zinc-coated wire. For epoxy-coated reinforcement, provide

nylon-, epoxy-, or plastic-coated wire. Where tie wire is in close proximity to finish surfaces of exposed-to-view concrete, provide soft stainless steel wire.

K. Welding Electrodes: E90XX low hydrogen electrodes (for shielded metal arc welding.)

L. Exothermic Metal-Filled Sleeve Coupler:

1. System Description: Provide bar splicing connection, produced by a standard exothermic process whereby molten filler metal, contained by a high-strength steel sleeve of larger inside diameter than adjoining bars, is introduced into the annular space between the bars and the sleeve as well as between the ends of the bars. Splicing system shall produce complete fusion with 100 percent penetration of the joint.
2. Spliced Strength in Tension: 125 percent of the yield strength of connected reinforcing bars.

M. Mechanical Splice Coupler:

1. System Description: Provide bar-splicing connections, produced by threaded reinforcing bar ends and threaded coupler, or by sleeves hydraulically pressed or forged onto butt-ended reinforcing bars, or by other proprietary mechanical splicing method as approved by the Contractor's engineer. Mechanical splice couplers shall be capable of being installed in the clear space indicated and to provide the required clearances.
2. Spliced Strength in Tension: Minimum 125 percent of the yield strength of connected reinforcing bars, unless otherwise indicated.
3. Spliced Strength in Tension: Reinforcing steel where as indicated on the Construction Drawings with minimum 80,000 psi yield strength couplers that are required to develop the higher strength of the reinforcing bars connected shall conform to Caltrans Standard Specifications Section 52-6.

2.2 FABRICATION

A. Fabrication Standards: Fabrication of steel reinforcement shall be in accordance with the Construction Drawings and approved shop drawings. Where specific details are not indicated, comply with applicable requirements of ACI 301, ACI 318, and CRSI Manual of Standard Practice.

B. Cutting and Bending: Cutting and bending shall be performed at a central location, equipped and suitable for the purpose. Bars shall be accurately cut and bent as indicated. Bars shall be bent cold. Heating of bars for bending or straightening will not be permitted. Bars shall not be bent or straightened in any manner, which will injure the material. Label all bars in accordance with bending diagrams and schedules, and secure like pieces in bundles when appropriate.

C. Welding:

1. Welding of reinforcement in aerial structures, bridges, grade separations, box culverts, earth retaining structures and cut and cover tunnels shall conform to Caltrans Standard Specifications Section 52-6.
2. Welding of reinforcement, where indicated and approved by the Contractor's engineer, including preparation of bars, shall conform to applicable requirements of AWS D1.4. Welders shall be prequalified in accordance with AWS D1.4, Chapter 6.

3. Use full penetration butt welds by the electric-arc method unless otherwise indicated or approved by the Contractor's engineer. Weld splices shall develop 125 percent of the specified yield strength of the bars, or of the smaller bar in transition splices.
4. Clean bars of oil, grease, dirt, and other foreign matter and flame-dry before welding. Preheat bars before welding in accordance with AWS D1.4, Chapter 5. Stagger splices in adjacent bars a minimum of 48 inches.
5. Tack welding on reinforcing bars will not be permitted.

D. Repair of Damaged Coatings: Bars for galvanized reinforcement shall be cut and bent cold before galvanizing. Galvanized and epoxy coatings damaged by shipping, handling, or cutting and bending shall be repaired as specified in ACI 301, and ASTM A767/A767M, ASTM A775/A775M, ASTM A884/A884M, and ASTM D3963/D3963M, as applicable.

2.3 IDENTIFICATION

A. Reinforcing steel shall be bundled and tagged with grades and sizes, heat numbers, and suitable identification marks for checking, sorting, and placing. Sizes and mark numbers shall correspond to placing shop drawings and schedules. Tags and markings shall be water-resistant and shall not be removed until steel reinforcement is placed in position.

2.4 TOLERANCES

A. Fabrication: Fabricate bars to meet the following tolerances:

1. Sheared length: plus or minus 1 inch.
2. Depth of truss bars: plus 0, minus 1/2 inch.
3. Overall dimensions of stirrups, ties and spirals: plus or minus 1/2 inch.
4. All other bends: plus or minus 1 inch.
5. Fabrication tolerances not indicated on the Construction Drawings or specified above shall comply with the applicable requirements of ACI 301 and CRSI Manual of Standard Practice, Chapter 7.

2.5 REINFORCING STEEL FOR DUCT BANKS

A. Reinforcing steel shall be provided for duct banks. Longitudinal steel shall be provided with a minimum total cross sectional area of 0.0018 times the gross area of the duct bank. The maximum spacing of reinforcing bars shall be 18 inches, with a minimum of one bar provided in each corner. Tie bars in the transverse direction enclosing the longitudinal steel bars shall also be provided, with a minimum size of No. 3 bars at a minimum spacing of 12 inches. The minimum clear concrete cover over reinforcing steel shall be 3 inches where concrete is cast directly against earth, and 1-1/2 inches where concrete is cast directly against fabricated formwork.

B. Where duct banks enter rigid underground structures, reinforcing steel shall be provided to tie the duct bank to the structure. Details shall be provided showing methods used to prevent damage to duct banks due to differential settlement at these points.

PART 3 - EXECUTION

3.1 VERIFICATION OF CONDITIONS

A. Verify that surfaces, over or against which concrete is to be placed, are clean and in proper condition for placing reinforcement.

B. Verify that items to be embedded in concrete inserts, sleeves, and block-outs are secured in place as required.

3.2 PLACING

A. Placing Standards: Reinforcing steel shall be placed in accordance with the Construction Drawings, approved shop drawings, and the applicable requirements of ACI 301, ACI 318, CRSI Manual of Standard Practice, and CRSI Placing Reinforcing Bars. Install reinforcement accurately and secure against movement, particularly under the weight of workers and the placement of concrete.

B. Reinforcing Supports: Bars shall be supported on metal or plastic chairs, spacers, and hangers, accurately placed and securely fastened to steel reinforcement in place. Support legs of accessories in forms without embedding in the form surface. Hoops and stirrups shall be accurately spaced and wired to the reinforcement.

C. Placing and Tying: Reinforcing steel shall be installed in place, spaced, and rigidly and securely tied or wired with tie wire at all splices and at crossing points and intersections in the positions indicated. It is not necessary to tie bars at every intersection. Comply with requirements of CRSI Placing Reinforcing Bars, Chapter 10. Snap ties are acceptable for intermediate intersections. Rebending of bars on the job to fit different conditions will not be permitted. Point ends of wire ties away from adjacent form surfaces.

D. Spacing: Center-to-center distance between parallel bars shall be in accordance with the Construction Drawings or, where not indicated, the minimum clear spacing shall be in accordance with ACI 318.

E. Longitudinal Location of Bends and Ends of Bar: A maximum of plus or minus 3 inches from the indicated location will be permitted, provided that specified protective concrete cover at ends of members is not reduced by more than 1/2 inch.

F. Splices:

1. Reinforcing bar splices in aerial structures, bridges, grade separations, box culverts, earth retaining structures and cut and cover tunnels shall conform to Caltrans Standard Specifications Section 52-6.
2. Lapped Splices:
    a. Laps of splices shall be securely tied together to maintain the alignment of the bars, to provide the required minimum clearances, and to transfer stress by bond. Lapped splices and development lengths not shown shall be detailed to develop Class B lapping lengths and development lengths in tension, respectively, in accordance with ACI 318.
    b. Splices of alternate bars shall be staggered a minimum clear offset of 2 feet between splices. Splices shall be tied with tie wire, or splices may be lap welded in

accordance with AWS D1.4. Lapped splices are not permitted for No. 14 and No. 18 bars, or when specifically excluded by Contract provisions regardless of size.

3. Exothermic Metal-Filled Coupler Splices: Comply with the product manufacturer's installation instructions and recommendations and with applicable requirements of AWS D1.4 for exothermic welding.
4. Mechanical Coupler Splices: Perform installation of coupler and tightening of joint assembly in accordance with the coupler manufacturer's installation instructions and recommendations.
   a. Reinforcing bars to be joined shall be shop threaded using special machinery to produce the required tapered threads. Where previously threaded bars must be cut or where threads are damaged, bars shall be replaced, or an alternate splicing system approved by the Contractor's engineer shall be substituted. Bars shall not be rethreaded, and damaged threads shall not be repaired in the field.
   b. Prior to joining, inspect all threads and assure that they have been properly made and are clean.
   c. Rotate coupler and bar initially by hand or wrench until snug (approximately 3-1/4 to 4 turns). Apply 24-inch minimum pipe wrench and turn coupler (or bar) until further turning is resisted with the application of a minimum torque of 200 foot-pounds. Suitably mark joint to indicate that tightening has been completed.
   d. For proprietary mechanical splicing systems not specified herein, installation shall comply with the manufacturer's installation instructions.

5. Spiral Reinforcement Splices: Splices shall conform to applicable requirements of Caltrans Standard Specifications Section 52-6.

G. Dowels: Provide dowels where indicated or required for connecting construction and for maintaining structural and reinforcement continuity. Dowels shall be tied securely in place before concrete is deposited. Provide additional bars for proper support and anchorage where required. Do not bend dowels after embedment.

H. Welded Wire Fabric:

1. Wire fabric shall be installed in lengths as long as practicable and shall be wire-tied at all laps and splices. End laps shall be offset in adjacent widths. Lap welded wire fabric in accordance with applicable requirements of ACI 318.
2. Where required welded wire fabric shall be secured in position with suitable supports, accessories, and tie wire as indicated and required to ensure against movement from workers and placement of concrete lift fabric as concrete is placed to assure proper embedment at position indicated.

3.3 PROTECTIVE CONCRETE COVER

A. Minimum concrete coverage for steel reinforcement shall be as specified in ACI 301, ACI 318, or CRSI Manual of Standard Practice. If there is a conflict between the standards specified, the thicker concrete coverage shall govern.

3.4 TOLERANCES

A. Placement: Place bars to the following tolerances:

1. Clear distance to formed surfaces: plus or minus 1/4 inch.

2. Minimum spacing between bars: minus 1/4 inch.
3. Top bars in slabs and beams:
   a. Member 8 inches deep or less: plus or minus 1/4 inch.
   b. Member greater than 8 inches, but less than 2 feet deep: plus or minus 1/2 inch.
   c. Members 2 feet or more deep: plus or minus 1 inch.

4. Crosswise of members: spaced evenly within 2 inches.
5. Lengthwise of members: plus or minus 2 inches.
6. Placement tolerances not indicated on the Construction Drawings or specified above shall comply with the requirements of ACI 301, ACI 318, or CRSI Manual of Standard Practice, as applicable.

3.5 CLEANING

A. Reinforcement at time of depositing concrete shall be free of corrosion and coatings that may impair bond with concrete, such as form oil, mill scale, or loose deposits of rust and other corrosion.

3.6 FIELD QUALITY CONTROL

A. Quality control inspections and tests to be performed by the Contractor and Contractor-hired testing laboratory include the following, at minimum:

1. Placement of Reinforcing Steel: Visual inspection of reinforcing steel in place, including bar supports, tied laps and intersections, welded wire fabric, and bar mats.
2. Welds:
   a. Visual inspection of reinforcing bar welds.
   b. Tension tests of welded butt joints. Tests shall be performed on sample welds produced by the Contractor in accordance with ASTM E8.
   c. Nondestructive tests of installed welded butt joints shall be performed in accordance with ASTM E165.
   d. Inspections and tests shall be performed in accordance with the applicable requirements of AWS D1.4, Chapters 6 and 7.

3. Exothermic/Coupler Splices:
   a. Continuous visual inspection for the first eight hours, minimum, of the work as performed by any crew, and again by any replacement crew. All splices require visual inspection before concrete may be placed.
   b. Visual inspection shall be performed in accordance with the product manufacturer's instructions and recommendations for such inspection.
   c. Inspections shall measure and record all voids. Exothermic rebar splices shall be accepted, provided measured "void limits," per end, do not exceed manufacturer's specified "void limits."
   d. Splices indicating improper fill, slag at tap hole, or blowouts shall be rejected.

4. Mechanical Coupler Splices: Test 100 percent of the couplers, using a 24-inch click-type torque wrench calibrated to 200 foot-pounds. Minimum turning torque of 200 foot-pounds shall be applied to the extent that further turning is resisted. Where tests reveal failure of couplers to be properly tightened, couplers shall be removed and replaced.
5. Exothermic/Coupler Splices: the Contractor shall test qualification splices for each position as follows:

a. One sister splice for the first 25 splices; thereafter, one sister splice for every 50 splices.
b. Sister splices shall be laboratory tested for strength in tension (125 percent of the yield strength of connecting bars).

END OF SECTION

SECTION 03 30 00

CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Conveying and placing concrete.

B. Placement under water.

C. Consolidation.

D. Construction joints.

E. Expansion and contraction joints.

F. Curing and protection.

1.2 RELATED SECTIONS

A. Portland cement concrete specified in Section 03 05 15, Portland Cement Concrete.

B. Finishing and curing of formed and unformed concrete surfaces, including repair and patching of surface defects, are specified in Section 03 35 00, Concrete Finishing.

C. Shotcrete is specified in Section 03 37 13, Shotcrete.

1.3 REFERENCED STANDARDS

A. American Concrete Institute (ACI):

1.	ACI 117	Specification for Tolerances for Concrete Construction and Materials and Commentary
2.	ACI 301	Specifications for Structural Concrete
3.	ACI 302.1R	Guide for Concrete Floor and Slab Construction
4.	ACI 303.1	Standard Specification for Cast-In-Place Architectural Concrete
5.	ACI 304R	Guide for Measuring, Mixing, Transporting, and Placing Concrete
6.	ACI 304.2R	Placing Concrete by Pumping Methods
7.	ACI 305R	Guide to Hot Weather Concreting
8.	ACI 306.1	Standard Specification for Cold Weather Concreting
9.	ACI 308R	Guide to Curing Concrete
10.	ACI 309R	Guide for Consolidation of Concrete
11.	ACI 318	Building Code Requirements for Structural Concrete and Commentary
12.	ACI 503.2	Standard Specification for Bonding Plastic Concrete to Hardened Concrete with a Multi-Component Epoxy Adhesive

B. ASTM International (ASTM):

1. ASTM C31 Standard Practice of Making and Curing Concrete Test Specimens in the Field
2. ASTM C94 Standard Specification for Ready-Mixed Concrete
3. ASTM C881 Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete

1.4 SUBMITTALS

A. Shop Drawings:

1. Submit drawings that indicate the locations of all joints in concrete, including construction joints, expansion joints, isolation joints, and contraction joints. Coordinate with the requirements specified in Section 03 11 00, Concrete Forming.
2. Submit drawings that indicate concrete placement schedule, method, sequence, location, and boundaries. Include each type and class of concrete, and quantity in cubic yards.

B. Product Data: Submit manufacturer's product data for epoxy adhesive.

C. Records and Reports: Report the location in the finished work of each mix design, and the start and completion times of placement of each batch of concrete placed for each date concrete is placed.

1.5 QUALITY ASSURANCE

A. Tolerances:

1. Concrete Tolerances: Comply with the requirements of ACI 117 as applicable. Coordinate with the requirements specified in Section 03 11 00, Concrete Forming.
2. Tolerances for Slabs and Flatwork: Comply with the requirements specified in Section 03 35 00, Concrete Finishing.

B. Architectural Concrete: Where concrete is indicated as architectural concrete exposed to public view, such concrete shall be produced in accordance with applicable requirements of ACI 301 and ACI 303.1.

C. Site Mock-Ups:

1. Construct site mock-ups for all architectural concrete work and formed concrete that will be exposed to the public in the finished work, not less than 4 feet by 6 feet in surface area, for review and acceptance by the Contracting Officer, before starting the placement of concrete.
2. Accepted site mock-ups shall set the standard for the various architectural concrete features, formed finishes, and colors of the concrete. Provide as many mock-ups as required to show all the different features and formed surfaces of the concrete.

D. Cold Joints: Cold joints in concrete will not be permitted unless planned and treated properly as construction joints.

E. Monitoring of Formwork: Provide monitoring of forms and embedded items to detect movement, or forms and embedded items out-of-alignment, from pressure of concrete placement.

1.6 ENVIRONMENTAL REQUIREMENTS

A. Delivering and placing of concrete in hot weather and cold weather shall comply with applicable requirements of ACI 305R and ACI 306.1 and Section 03 05 15, Portland Cement Concrete.

B. Do not place concrete when the rate of evaporation of surface moisture from concrete exceeds 0.2 pound per square foot per hour as indicated in Figure 2.1.5 of ACI 305R.

C. Do not place concrete in, or adjacent to, any structure where piles are required until all piles in the structure have been driven or installed.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Portland Cement Concrete: Refer to Section 03 05 15, Portland Cement Concrete, for mix designs and other requirements.

B. Formwork: Refer to Section 03 11 00, Concrete Forming, for requirements.

C. Joint Fillers and Sealers: Refer to Section 03 15 00, Concrete Accessories, for requirements.

D. Waterstops: Refer to Section 03 15 13, Waterstops, for requirements.

E. Reinforcing Steel: Refer to Section 03 20 00, Concrete Reinforcing, for requirements.

F. Concrete Curing Materials: Refer to Section 03 35 00, Concrete Finishing, for requirements.

G. Epoxy Adhesive: ASTM C881, Type II for non-load-bearing concrete and Type V for load-bearing concrete, Grade and Class as determined by project conditions and requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Inspect forms, earth bearing surfaces, reinforcement, and embedded items, and obtain the written approval in accordance with the Contractor's Quality Management Plan before placing concrete. Complete and sign a pour card on the form acceptable to the Contracting Officer. The Contractor's engineer shall countersign the card prior to commencing the pour.

3.2 PREPARATION

A. Place concrete under the observation of the Contractor's engineer and with the Contractor's Quality Control Representative present to document requirements and results of the placement.

B. Do not place concrete until conditions and facilities for the storage, handling, and transportation of concrete test specimens are in compliance with the requirements of ASTM C31 and Section 03 05 15, Portland Cement Concrete.

C. Prior to placement of concrete, the subgrade shall be in a firm, well-drained condition, and of adequate and uniform load-bearing nature to support construction personnel, construction

materials, construction equipment, and steel reinforcing mats without tracking, rutting, heaving, or settlement. All weak, soft, saturated, or otherwise unsuitable material shall be removed and replaced with structural backfill or lean concrete.

D. All structure foundations, including those for Stations and for subway box, shall be inspected and approved, in writing, by a qualified, independent geotechnical engineer prior to placement of footings and base slabs, to confirm the adequacy of the supporting soil for concrete placement.

E. Earth bottoms or bearing surfaces for footings and slabs shall be dampened but not saturated or muddied just before placing concrete.

3.3 TRANSPORTING

A. Concrete shall be central-mixed concrete from a central batch plant, transported to the jobsite in a truck mixer, in accordance with the requirements specified in Section 03 05 15, Portland Cement Concrete, and ASTM C94.

B. Transport concrete to the jobsite in a manner that will assure efficient delivery of concrete to the point of placement without adversely altering specified properties with regard to water-cement ratio, slump, air entrainment, and homogeneity.

3.4 CONVEYING AND PLACING

A. Placement Standards: Conveying and placing of concrete shall comply with applicable requirements of ACI 301, ACI 302.1R, ACI 304R, and ACI 318.

B. Handling and Depositing:

1. Concrete placing equipment shall have sufficient capacity to provide a placement rate that will preclude cold joints and that shall deposit the concrete without segregation or loss of ingredients.
2. Concrete placement, once started, shall be carried on as a continuous operation until the section of approved size and shape is completed.
3. Concrete shall be handled as rapidly as practicable from the mixer to the place of final deposit by methods that prevent the separation or loss of ingredients. Concrete shall be deposited, as nearly as practicable, in its final horizontal position to avoid redistribution or flowing.
4. Concrete shall not be dropped freely where reinforcing will cause segregation, nor shall it be dropped freely more than 5 feet. Concrete shall be deposited to maintain a plastic surface approximately horizontal.
5. In placing walls, columns, or thin sections (6 inches or less in thickness) of heights greater than 10 feet, concrete placement rate, lift thickness, and time intervals between lifts shall be as indicated on approved shop drawings. Openings in the form, elephant trunk tremies, or other approved devices, shall be used that will permit the concrete to be placed without segregation or accumulation of hardened concrete on the forms or metal reinforcement above the level of the fresh concrete.
6. Concrete that has partially hardened shall not be deposited in the work. The discharge of concrete shall be started not later than 60 minutes after the introduction of mixing water. Placing of concrete shall be completed within 90 minutes after the first introduction of water into the mix.

C. Pumping:

1. Concrete may be placed by pumping if the maximum slump can be maintained and if accepted in writing by the Contractor's engineer for the location proposed.
2. Placing concrete by pumping methods shall comply with applicable requirements of ACI 304R and ACI 304.2R.
3. Equipment for pumping shall be of such size and design as to ensure a continuous flow of concrete at the delivery end without separation of materials. Concrete from end of hose shall have a free fall of less than 5 feet. Pump hoses shall be supported on horses or similar devices so that reinforcement or post-tensioning ducts or tendons are not moved from their original position.
4. The concrete mix shall be designed to the same requirements as specified in Section 03 05 15, Portland Cement Concrete, and may be altered for placement purposes with the prior approval of the Contractor's engineer.

3.5 PLACEMENT UNDER WATER

A. Placement Standards: Placing of concrete in or under water shall conform to requirements of ACI 304R. All concrete to be placed under water shall be placed by the tremie method or by direct pumping.

B. Placement Requirements: Deposit concrete in water only when indicated or approved in writing by the Contractor's engineer and only under the observation of the Contractor's engineer. Use only tremie method and direct pumping with equipment that has been accepted by the Contractor's engineer.

3.6 CONSOLIDATION

A. Concrete shall be thoroughly consolidated and compacted by mechanical vibration during placement in accordance with the requirements of ACI 309R.

B. Concrete placement shall be inspected in accordance with Contractor's Quality Management Plan to confirm that proper placing methods are being employed, and that special techniques are being used in congested areas and around obstructions such as pipes and other embedded items. Check installation of embedded items for correct location and orientation during concrete placement.

C. Conduct vibration in a systematic manner by competent, skilled, and experienced workers, with regularly maintained vibrators, and with sufficient back-up units at the jobsite. Use the largest and most powerful vibrator that can be effectively operated in the given work, with a minimum frequency of 8,000 vibrations or impulses per minute, and of sufficient amplitude to effectively consolidate the concrete.

D. Insert and withdraw the vibrator vertically at uniform spacing over the entire area of the placement. Space the distance between insertions such that "spheres of influence" of each insertion overlap.

E. Conduct vibration so as to produce concrete that is of uniform texture and appearance, free of honeycombing, air and rock pockets, streaking, cold joints, and visible lift lines.

F. On vertical surfaces and on all architectural concrete where an as-cast finish is required, use additional vibration and spading as required to bring a full surface of mortar against the forms, so

as to eliminate objectionable air voids, bug holes, and other surface defects. Additional procedures for vibrating concrete shall consist of the following:

1. Reduce the distance between internal vibration insertions and increase the time for each insertion.
2. Insert the vibrator as close to the face of the form as possible, without contacting the form.
3. Use spading as a supplement to vibration at forms to provide fully filled out form surfaces without air holes and rock pockets.
4. Provide vibration of forms only if approved by the Contractor's engineer for the location.

3.7 CONSTRUCTION JOINTS

A. Construction joints will be permitted only where indicated or approved by the Contractor's engineer.

B. Provide and prepare construction joints and install waterstops in accordance with the applicable requirements of ACI 301 and ACI 304R, and as specified in Section 03 11 00, Concrete Forming.

C. Make construction joints straight and as inconspicuous as possible, and in exact vertical and horizontal alignment with the structure, as the case may be.

D. Use approved key, at least 1-1/2 inches in depth, at joints unless otherwise indicated or approved by the Contractor's engineer.

E. Thoroughly clean the surface of the concrete at construction joints and remove laitance, loose or defective concrete, coatings, sand, sealing compound and other foreign material. Prepare surfaces of joints by sandblasting or other approved methods to remove laitance and expose aggregate uniformly.

F. Immediately before new concrete is placed, wet the joint surfaces and remove standing water. To allow for shrinkage, do not place new concrete against the hardened concrete side of a construction joint for a minimum of 72 hours.

G. Locate joints that are not indicated so that the strength of the structure is not impaired. Joint types and their locations shall be reviewed and approved by the Contractor's engineer prior to concrete placement.

H. Ensure that reinforcement is continuous across construction joints.

I. Place waterstops in construction joints where indicated.

J. Where bonding of the joint is required, provide epoxy adhesive hereinbefore specified and apply in accordance with ACI 503.2.

K. Retighten forms and dampen concrete surfaces before concrete placing is continued.

L. Allow at least 72 hours to elapse before continuing concrete placement at a construction joint. Approval for accelerating the minimum time elapsing between adjacent placements will be based on tests and methods that confirm that a minimum moisture loss at a relatively constant temperature will be maintained for the period as necessary to control the heat of hydration and hardening of concrete, and to prevent shrinkage and thermal cracking.

3.8 EXPANSION AND CONTRACTION JOINTS

A. Refer to Section 03 11 00, Concrete Forming, for slab screeds and for formwork where expansion and contraction joints are indicated as architectural features, such as reveals or rustications.

B. Refer to Section 03 15 00, Concrete Accessories, for expansion joint filler material and joint sealing compound.

C. Refer to Section 03 35 00, Concrete Finishing, for finishing of edges of expansion joints in slabs with curved edging tool.

3.9 CURING AND PROTECTION

A. Curing of concrete shall comply with applicable requirements of ACI 301 and ACI 308R, except that the curing duration shall be a minimum period of ten days. Curing with earth, sand, sawdust, straw, and hay will not be permitted.

B. Keep concrete in a moist condition from the time it is placed until it has cured for at least 10 days. Keep forms damp and cool until removal of forms.

C. Immediately upon removal of forms, exposed concrete surfaces shall be kept moist by applying an approved curing compound or by covering with damp curing materials as specified in Section 03 35 00, Concrete Finishing.

D. Concrete shall not be permitted to dry during the curing period because of finishing operations.

E. Protect fresh concrete from hot sun, drying winds, rain, damage, or soiling. Fog spray freshly placed slabs after bleed water dissipates and after finishing operations commence. Allow no slabs to become dry at any time until finishing operations are complete.

F. Finishing and curing of slabs are specified in Section 03 35 00, Concrete Finishing.

G. Protect concrete from injurious action of the elements and defacement of any kind. Protect exposed concrete corners from traffic or use that will damage them in any way.

H. Protect concrete during the curing period from mechanical and physical stresses that may be caused by heavy equipment movement, subjecting the concrete to load stress, load shock, or excessive vibration.

3.10 REPAIR OF SURFACE DEFECTS

A. Refer to Section 03 35 00, Concrete Finishing, for requirements.

END OF SECTION

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SECTION 03 35 00

CONCRETE FINISHING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Repair of surface defects.

B. Finishing of formed surfaces.

C. Slabs and flatwork.

D. Curing.

E. Protection.

F. Tolerances.

1.2 RELATED SECTIONS

A. Concrete formwork is specified in Section 03 11 00, Concrete Forming.

B. Cast-in-place concrete is specified in Section 03 30 00, Cast-In-Place Concrete.

1.3 REFERENCE STANDARDS

A. American Association of State Highway and Transportation Officials (AASHTO):

1.	AASHTO M182	Standard Specification for Burlap Cloth Made from Jute or Kenaf and Cotton Mats

B. American Concrete Institute (ACI):

1.	ACI 117	Specification for Tolerances for Concrete Construction and Materials and Commentary
2.	ACI 301	Specifications for Structural Concrete
3.	ACI 308R	Guide to Curing Concrete
4.	ACI 503.4	Standard Specification for Repairing Concrete with Epoxy Mortars

C. ASTM International (ASTM):

1.	ASTM C33	Standard Specification for Concrete Aggregates
2.	ASTM C150	Standard Specification for Portland Cement
3.	ASTM C171	Standard Specifications for Sheet Materials for Curing Concrete
4.	ASTM C309	Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
5.	ASTM C779/C779	Standard Test Method for Abrasion Resistance of Horizontal Concrete Surfaces

6. ASTM C881 Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
7. ASTM E303 Standard Test Method for Measuring Surface Frictional Properties Using the British Pendulum Tester
8. ASTM E1155 Standard Test Method for Determining FF Floor Flatness and FL Floor Levelness Numbers

D. State of California, Department of Transportation (Caltrans), Standard Specifications:

1. Section 51 Concrete Structures

1.4 SUBMITTALS

A. Submittals involving concrete finishes exposed to public view require acceptance of the Contracting Officer before they may be incorporated in the Work.

B. Shop Drawings: Submit drawings, or diagrams to scale, that indicate the location in plan and elevation of all concrete finishes.

C. Product Data: Submit manufacturers' product data for manufactured products.

D. Samples:

1. Submit 1/2-pint sample container of aluminum oxide and silicon carbide abrasive grit for review and acceptance where "non-slip finish" is indicated.
2. Submit samples not less than 12 inches by 12 inches in size of each type of sand blast finish, indicating materials and methods used to produce the sand blast finishes. Review by the Contracting Officer will be for color and texture only. Accepted samples will become the Contracting Officer's control samples.

1.5 QUALITY ASSURANCE

A. Finishes:

1. Finishing of formed concrete surfaces shall conform to applicable requirements of ACI 301.
2. Finishes for slabs and flatwork shall conform to applicable requirements of ACI 301.
3. Special architectural finishes for formed concrete surfaces shall conform to applicable requirements of ACI 301.
4. Bridge deck finishes shall conform to applicable requirements of Caltrans Standard Specifications Section 51.

B. Curing: Conform to requirements of ACI 301 and ACI 308R, as applicable, and requirements specified herein.

C. Site Mock-Ups: Provide site mock-ups, at least 3 feet by 4 feet in size, of finishes of formed surfaces in exposed locations and of exposed slab finishes for the Contracting Officer's review and acceptance.

D. Site Mock-ups of Architectural Concrete: Provide site mock-ups of architectural concrete showing finish texture and pattern of exposed formed concrete surfaces.

1. Size of mock-up shall be a minimum of 8 feet by 10 feet, unless otherwise accepted by the Contracting Officer to be smaller.
2. The number of mock-up panels required shall be the number necessary to obtain the Contracting Officer's acceptance of pattern and texture of panel.
3. Accepted mock-up shall be used as the standard for the aesthetic quality of the surface finish of architectural concrete.

E. Requirements of Regulatory Agencies: Comply with air pollution regulations of governing authorities for sand-blasting activities and operations.

PART 2 - PRODUCTS

2.1 REPAIR AND FINISHING MATERIALS

A. Portland Cement: ASTM C150, Type II, of same brand as used in the work. Furnish white portland cement where required to produce color matching color of surrounding concrete.

B. Aggregate:

1. For Bonding Grout: ASTM C33, washed clean sand passing a No. 30 sieve.
2. For Patching Mortar: ASTM C33, washed clean, graded fine aggregate of suitable size for areas to be repaired. Clean coarse aggregate up to Size No. 8 may be added for repair of larger pockets and voids.

C. Commercial Patching Mortar: A structural repair mortar may be furnished if appropriate for the use and approved by the Contractor’s engineer.

D. Epoxy Patching Mortar: As specified in ACI 503.4 for Epoxy Mortar.

E. Epoxy Adhesive: ASTM C881, Type II or Type V, epoxy-based bonding agent.

F. Anti-Slip Abrasive Grit: Virgin grain Aluminum Oxide or Silicon Carbide particles, or a mixture of the two.

G. Concrete Floor Densifier, Hardener, and Sealer: Chemical which penetrates concrete to seal, densify, dustproof, and harden to resist water and oil penetration, and contamination. Product shall meet the following characteristics:

1. Abrasion resistant: When tested in accordance with ASTM C779, product shall increase wear resistance a minimum of 200 percent.
2. Slip resistant. Product shall demonstrate good slip resistance when tested in accordance with ASTM E303. SCOF: Wet or dry: 0.6 or greater.

2.2 CURING MATERIALS

A. Damp Curing Materials:

1. Waterproof Sheet Materials: ASTM C171, waterproof paper with white paper face, polyethylene film pigmented white, or white burlap-polyethylene sheeting.
2. Burlap: AASHTO M182, of class or weight suitable for the use and location. Do not use burlap where concrete is exposed to direct sunlight.

B. Curing Compound: ASTM C309, liquid membrane-forming curing compound, Type 1, Class A or B as appropriate for the use or location.

   1. Where concrete surfaces will receive architectural finishes, such as resilient floor coverings or paint, or membrane waterproofing, membrane-forming curing compound shall not leave a coating or residue that will impair bond of adhesives, paints, and coatings with concrete.

PART 3 - EXECUTION

3.1 REPAIR OF SURFACE DEFECTS

A. Repair Standards: Repair of surface defects shall comply with applicable requirements of ACI 301. When using epoxy mortar, comply with applicable requirements of ACI 503.4.

B. Surface Defects:

   1. Repair of surface defects shall begin immediately after form removal. For repair with epoxy mortar, concrete shall be dry.
   2. Surface defects are defined to include: form-tie holes, air voids or pockets, bug holes with a nominal diameter or depth greater than 1/4-inch, honeycombed areas, rock pockets, visible construction joints, fins and burrs.
   3. Repair of surface defects shall be tightly bonded and shall result in concrete surfaces of uniform color and texture, matching adjacent surfaces, and free of shrinkage cracks.

C. Repair Work:

   1. Remove honeycombed and other defective concrete down to sound concrete. Saw-cut the edges perpendicular to the surface or slightly undercut. Feather-edges will not be permitted. Dampen the area to be patched and an area at least 6 inches wide surrounding it to prevent absorption of water from the patching mortar.
   2. Where rock pockets or similar defects or voids expose steel reinforcement, cutout to solid surface behind the reinforcing steel to provide suitable key-lock for patching mortar. Patching mortar shall envelope the exposed reinforcing bar.
   3. Bond patching mortar to concrete with bonding grout or epoxy adhesive. Bonding grout shall consist of 1 part portland cement to 1 part No. 30 mesh sand, mixed to the consistency of a thick cream, and then well brushed onto the concrete. Bond commercial patching mortar to concrete in accordance with the manufacturer's instructions.
   4. Make the patching mortar of the same materials and of approximately the same proportions as used for the concrete, except omit the coarse aggregate. Use not more than 1 part portland cement to 2-1/2 parts sand by damp loose volume, and substitute white portland cement for a portion of the regular gray portland cement to produce patching mix matching the surrounding concrete in color when dry. Determine the proportion of white portland cement by trial mixes and test areas, prior to repair of actual defective areas.
   5. After surface water has evaporated from the area to be patched, brush the bond coat well into the surface. When the bond coat begins to lose the water sheen, apply the patching mortar. Compact the mortar into place and strike off so as to leave the patch slightly higher than the surrounding surface. To permit initial shrinkage, leave the patch undisturbed for at least 1 hour before being finally finished. Keep the patched area damp for 7 days.
   6. Neatly finish patched surfaces to match adjacent surrounding surface texture of concrete. Grind or fill surfaces to produce level and plumb, true planes.

7. For walls exposed in the finish work, form tie holes shall be patched and finished flush with adjacent surface. For holes passing entirely through walls, a plunger type injection gun or other suitable device shall be used to completely fill the holes.
8. Patching of honeycombed areas or rock pockets that are too large and unsatisfactory for mortar patching shall be cut out to solid surface, keyed, and packed solid with matching concrete to produce firm bond and flush surface. Patching shall match texture of adjacent surfaces where exposed in the finished work.
9. Repair work in exposed locations that does not match the texture and color of surrounding adjacent surfaces or that was not well performed shall be removed and performed again until the repair work conforms to Specification requirements.
10. Surfaces to receive membrane waterproofing shall have fins and loose material removed, and voids and cracks patched flush with adjacent surfaces.
11. Completed repairs shall be cured as herein specified under Article entitles “Curing.”

3.2 FINISHING OF FORMED SURFACES

A. Unexposed Surfaces:

1. Concrete that will not be exposed in the completed structure shall be any form finish as specified in Section 03 11 00, Concrete Forming, and ACI 301 for "rough form finish."
2. Concrete to receive membrane waterproofing shall receive a "smooth form finish" in accordance with ACI 301.

B. Exposed Surfaces: Unless indicated otherwise, concrete that will be exposed in the completed structure shall receive the following finishes as indicated:

1. Smooth Form Finish: Conform to ACI 301.
2. Smooth Rubbed Finish: Conform to ACI 301.
3. Grout Cleaned Finish: Conform to ACI 301.
4. Unspecified Finish: When finish is not indicated, provide "smooth form finish" as specified above.

C. Sand Blast Finish:

1. Blasting Operations and Requirements:
   a. Apply sandblasted finish to exposed concrete surfaces where indicated.
   b. Perform sand blasting at least 72 hours after placement of concrete. Coordinate with formwork construction, concrete placement schedule, and formwork removal to ensure that surfaces to be blast finished are blasted at the same age for uniform results.
   c. Determine type of nozzle, nozzle pressure, and blasting techniques required to match the Contracting Officer's control samples.
   d. Abrasive blast corners and edge of patterns carefully, using back-up boards, to maintain uniform corner or edge line.

2. Depths of Cut: Use an abrasive grit of proper type and gradation to expose aggregate and surrounding matrix surface to match the Contracting Officer's control samples as follows:
   a. Brush Sand Blast Finish: Remove cement matrix to expose face of fine aggregate; no reveal.
   b. Light Sand Blast Finish: Expose fine aggregate with occasional exposure of coarse aggregate; maximum 1/16-inch reveal.

c. Medium Sand Blast Finish: Generally expose coarse aggregate; 3/16-inch to 1/4-inch reveal.

3. Surface Continuity: Perform sand blast finishing in as continuous an operation as possible, utilizing the same work crew to maintain continuity of finish on each surface or area of work. Maintain patterns of variances in depths of cuts as indicated.
4. Construction Joints: Use technique acceptable to the Contractor’s engineer to achieve uniform treatment of construction joints.
5. Protection and Repair:
   a. Protect adjacent materials and finishes from dust, dirt, and other surface or physical damage during abrasive blast finishing operations. Provide protection as required and remove from site at completion of the work.
   b. Repair or replace other work damaged by finishing operations.

6. Clean-up: Maintain control of concrete chips, dust, and debris in each area of the work. Clean up and remove such material at the completion of each day of operation. Prevent migration of airborne materials by use of tarpaulins, windbreaks, and similar containment devices.

3.3 SLABS AND FLATWORK

A. Placement and Finishing Standards: Slabs and flatwork shall be placed, consolidated, and finished in accordance with applicable requirements of ACI 301. Coordinate with Section 03 30 00, Cast-In-Place Concrete, as applicable.

B. Placement:

1. Slabs and flatwork shall be placed and finished monolithically. Strike off and screed slabs to true, plane surfaces at required elevations, and thoroughly compact concrete with vibrators, floats, and tampers to force coarse aggregate below the surface. Finish slab within 4 hours of concrete placement.
2. Whether indicated or not, in areas where drains occur, slope finished slab to drains. Slope shall be a minimum of 1/8-inch per foot unless otherwise indicated.

C. Slab Finishes: Unless indicated otherwise, slabs and flatwork shall receive the following finishes as indicated:

1. Scratched Finish: Conform to ACI 301. Provide "scratched finish" for slab substrates to receive cementitious toppings or finishes, such mortar setting bed for ceramic tile.
2. Floated Finish: Conform to ACI 301. Provide "floated finish" for track slabs and mud slabs and for slabs and flatwork to receive roofing and membrane waterproofing.
3. Troweled Finish: Conform to ACI 301. Provide "troweled finish" for interior slabs and flatwork to be exposed in the completed structure, for slabs to receive resilient floor coverings, and for flatwork to receive elastomeric bearing pads.
4. Broom Finish: Conform to ACI 301. Exact texture and coarseness of the broom finish shall match the accepted site mock-up. Provide fine or medium-coarse "broom finish" as indicated for exterior sidewalks and paving, exterior ramps, equipment and transformer pads, and subway invert slab.
5. Nonslip Finish: Conform to ACI 301. Nonslip materials shall be aluminum oxide and silicon carbide grit particles. Provide "nonslip finish" for interior pedestrian ramps, walkways, subway cross-passage floors, and other floor areas where indicated.

6. Swirl Pattern Finish: Provide for garage floors. After basic floating operations have been completed, hand float slabs using wood float to product a continuous swirl patterned surface, free from porous spots, irregularities, depressions, and small pockets or rough spots such as may be caused by accidentally disturbing particles of coarse aggregate embedded near surface. Use natural arm circular motion to produce rows of approximately 1-foot radius swirl pattern covering approximately half of the preceding row with each successive row.
7. Unspecified Finish: When finish is not indicated or specified, provide finishes as specified in ACI 301.

D. Surface Tolerances: As specified herein:

1. Flat Tolerance: Slabs and flatwork with "troweled finish" and with "nonslip finish."
2. Straightedge Tolerance: Slabs and flatwork with fine "broom finish" or medium-coarse "broom finish."
3. Bull Floated Tolerance: Slabs and flatwork with "scratched finish," with "floated finish," and with coarse "broom finish."

E. Joints:

1. Construction, expansion, isolation, and contraction joints shall be located as indicated. Construction joints shall act as contraction joints. Where additional contraction joints are required to prevent shrinkage cracks, saw-cut such joints. All joints shall be straight and true to line.
2. Mark-off lines or edges at formed construction and expansion joints shall be finished with 1/4-inch radius curved edging tool, neat and true to line, uniform throughout.

F. Densifier, Hardener, and Sealer: Apply in accordance with manufacturer’s written instructions where floor hardener is indicated on the Construction Drawings.

3.4 CURING

A. Curing Standards: Curing of concrete shall comply with applicable requirements of ACI 301 and ACI 308R, except that the duration of the curing period shall be 10 days. Curing with earth, sand, sawdust, straw, and hay will not be permitted.

B. Curing Requirements:

1. Concrete shall be cured with waterproof sheet materials, damp burlap, or curing compounds.
2. Curing compounds shall not be used on top of ballasted aerial structures and on surfaces when their use may be detrimental to bonding of concrete, mortar, membrane waterproofing, calking and sealants, adhesives, plaster, paint, or the specified surface finish or coating.

C. Damp Curing:

1. Vertical surfaces shall be cured by keeping the forms wet at all times and by leaving the forms in place as long as possible as specified in Section 03 11 00, Concrete Forming. After removal of forms, concrete shall be kept continuously damp by fog spraying or otherwise washing down the concrete in an accepted manner until ten days after placing.

Protect exposed surfaces by covering with sheet materials or burlap kept continuously moist.

2. Horizontal surfaces shall be cured and protected by covering the finished surfaces with waterproof sheet materials or damp burlap, left in place for a minimum of 10 days and kept continuously moist.
3. Fog spray freshly placed slabs until finishing operations commence. Do not allow slabs to become dry until finishing operations are complete.

D. Curing Compound: Application of curing compound shall conform to applicable requirements of ACI 308.

3.5 PROTECTION

A. Protect exposed concrete surfaces, including flatwork, as required to prevent damage from impact or strains.

B. Protect fresh concrete from drying winds, rain, damage, or soiling.

C. Refer to Section 03 30 00, Cast-In-Place Concrete, Article entitled “Curing and Protection”, for additional requirements.

3.6 TOLERANCES

A. Formed Surfaces: Comply with applicable requirements of ACI 117.

1. Where elastomeric bearing pads are indicated, the level plane upon which bearing pads are placed shall not vary more than 1/16-inch from a 10-foot straightedge placed in any direction across the area and the area shall extend a minimum of 1 inch beyond the limits of the pads.
2. Bearing surfaces of girders on a slope or girders with a camber shall be finished on a horizontal/level plane so that loads are uniformly distributed over the entire surface of the elastomeric bearing pads.
3. The finished plane shall not vary more than 1/8-inch from the elevation indicated.

B. Slabs and Flatwork: Conform to applicable classification requirements of ASTM E1155, as follows:

Floor Profile Category	Specified Overall Value		Minimum Local Value		True plane with maximum variation in 10 feet when meas-ured with a 10-foot straight-edged placed anywhere in slab in any direction.
	F_F	F_L	F_F	F_L	
Very Flat	75	50	38	25	1/8 inch
Flat	50	33	25	17	3/16 inch
Conventional (Using highway straightedge)	25	17	13	10	5/16 inch
Conventional (using bullfloat)	19	13	13	10	1/2 inch

END OF SECTION

SECTION 03 37 13

SHOTCRETE

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Preparation of substrate surfaces.

B. Shotcrete placement.

C. Curing.

1.2 REFERENCE STANDARDS

A. American Concrete Institute (ACI):

1. ACI 506.2 Specification for Shotcrete
2. ACI 506.3R Guide to Certification of Shotcrete Nozzlemen

B. ASTM International (ASTM):

1. ASTM C31 Standard Practice for Making and Curing Concrete Test Specimens in the Field
2. ASTM C33 Standard Specification for Concrete Aggregates
3. ASTM C42 Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
4. ASTM C94 Standard Specification for Ready-Mixed Concrete
5. ASTM C150 Standard Specification for Portland Cement
6. ASTM C494 Standard Specification for Chemical Admixtures for Concrete
7. ASTM E329 Standard Specification for Agencies Engaged in the Construction Inspection, Special Inspection, or Testing Materials Used in Construction

1.3 DEFINITIONS

A. "Shotcrete" is defined as pneumatically placed concrete: A Portland-cement concrete mixture conveyed through a hose and nozzle, and shot onto a surface at high speed by means of air pressure.

1.4 SUBMITTALS

A. Submittals shall include the following requirements:

1. Mix design.
2. Methods of application and equipment.
3. Curing methods.
4. Certificates of compliance for materials.
5. Affidavit of compliance with ACI 506.3R for nozzle operators.
6. Test results.
7. Sample test panels.

B. Qualifications of laboratory, agency, mill or ready-mix plant proposed to perform mix designs.

1.5 QUALITY ASSURANCE

A. Shotcrete work shall be performed by a firm or company regularly engaged in the business of applying shotcrete materials, using nozzle operators and workers skilled and experienced in the type of work specified.

B. Shotcrete supervisor shall have not less than 2 years experience as a shotcrete nozzle operator.

C. Nozzle operator shall have not less than 1-year experience and, upon request of the Contracting Officer, shall demonstrate ability to properly place shotcrete.

D. Proof of compliance with ACI 506.3R shall be furnished for each nozzle operator.

E. Source of Mix Designs: Mix designs shall be obtained by the Contractor from a qualified independent testing laboratory or agency, or from a mill or ready-mix plant, properly equipped to design shotcrete/concrete mixes. The laboratory, agency, mill or ready-mix plant shall meet the applicable requirements of ASTM E329. The mix designs shall be certified and signed by a professional engineer who is currently registered as a civil or structural engineer in the State of California.

1.6 ENVIRONMENTAL CONDITIONS

A. Shotcrete shall not be placed during inclement or windy weather.

B. Proper protective clothing shall be worn by operators, and all personnel in the area shall wear masks during shotcreting until operations are stopped and the dust has cleared.

1.7 PROTECTION

A. Protect adjacent surfaces from overspray and damage due to shotcreting operations. Prevent dust nuisance.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Portland Cement: ASTM C150, Type II. Type III cement may be used, subject to written approval of the Contractor's engineer.

B. Aggregate: ASTM C33 normal weight aggregate with combined gradation of coarse and fine aggregates conforming to ACI 506.2, Gradation No. 1 or Gradation No. 2, as applicable to the work.

1. Maximum aggregate size may be varied, subject to acceptance by the Contractor's engineer.
2. Specific gravity of aggregate shall be not less than 2.50.

C. Water: Clean and potable, free of impurities detrimental to shotcrete.

D. Admixture: ASTM C494, Type C, or Type E containing no water-soluble chlorides or materials corrosive to steel or other properties that may cause cracking or spalling (for wet-mix shotcrete only.)

E. Ground Wires: No. 18 or 20-gage steel annealed wire.

F. Thickness Pins: Noncorrosive thickness-indication pins designed not to cause infiltration of water through shotcrete.

G. Reinforcing Steel: Comply with applicable requirements of Section 03 20 00, Concrete Reinforcing.

2.2 MIX DESIGN

A. Design of shotcrete mix, whether dry-mix shotcrete or wet-mix shotcrete, including recommended amounts of admixture and water to be used, shall be obtained by the Contractor from a qualified independent testing laboratory or agency, or from a mill or ready-mix plant, properly equipped to design shotcrete/concrete mixes.

B. Shotcrete mix shall conform with the following requirements:

1. Proportion of cement to aggregate shall be as required to achieve the indicated or specified strength.
2. Water content at time of discharge from nozzle shall not exceed amount required to achieve the maximum permitted slump.
3. Compressive strength of shotcrete shall be not less than the indicated or specified 28-day compressive strength (pounds per square inch).

C. Shotcrete shall not be placed until the submitted mix design has been approved by the Contractor's engineer in writing.

2.3 EQUIPMENT AND MIXING

A. Equipment Standards: Equipment shall be appropriate and suitable for dry-mix or wet-mix shotcrete, as applicable, in accordance with the requirements of ACI 506.2.

B. Batching and Mixing Equipment: Materials shall be batched by weight and machine mixed, and delivered to the site pre-mixed. For wet-mix shotcrete, conform to the applicable requirements of ASTM C94 for ready-mixed concrete.

C. Delivery Equipment: Conform to the applicable requirements of ACI 506.2. Equipment shall be capable of discharging mixture into delivery hose under close control and shall deliver a continuous stream of material at the proper volume to discharge nozzle. Discharge nozzle shall be equipped with a manually operated and adjustable air-injection system for directing an even distribution of air through the mixture. Nozzle shall deliver a conical discharge stream of uniform appearance. Equipment shall be cleaned daily and inspected for worn parts. Plaster guns are not permitted.

D. Air Supply: System shall employ a properly operating compressor of ample capacity to perform the work. Comply with capacity requirements specified in ACI 506.2, with modification for hose lengths and working heights.

PART 3 - EXECUTION

3.1 EXAMINATION OF SUBSTRATE SURFACES

A. Examine earth, rock, concrete, and masonry substrate surfaces, as applicable, and determine that such substrate surfaces have been properly prepared as hereinafter specified under Article entitled "Preparation of Substrate Surfaces."

B. Inspect soil anchors and determine that they are of correct size and type, and properly located and installed.

C. Inspect reinforcing steel and determine that it is properly placed and tied, that sufficient clearances have been provided, and that it is free of grease, oil, loose rust, and other coatings that may impair bond with concrete.

D. Assure that sleeves and other items to be embedded in shotcrete are in place and that provisions for penetrations have been made.

E. Proceeding with shotcrete placement shall imply acceptance of substrate surfaces and conditions as satisfactory.

3.2 PREPARATION OF SUBSTRATE SURFACES

A. Prepare earth, rock, concrete, and masonry substrate surfaces, as applicable, in accordance with ACI 506.2.

B. Rock faces shall be free of loose rock.

C. Absorptive substrate surfaces shall be evenly dampened before placing shotcrete.

D. Formwork shall be designed and constructed to provide for escape of compressed air and rebound during shotcrete placement. Coordinate with Section 03 11 00, Concrete Forming.

E. Drain any free-standing water away from shotcrete operations.

F. Provide ground wires to establish thickness and surface planes. Install vertically and horizontally as required. Do not penetrate waterproof membranes.

G. As an alternative to ground wires, thickness-measuring pins may be used to establish layer thickness and surface plane, provided such pins do not penetrate waterproof membranes and do not detrimentally damage substrates. Install pins on 5-foot centers in each direction.

3.3 SHOTCRETE PLACEMENT

A. Operation and Placement Standards: Shotcrete operations and placement shall conform to the applicable requirements of ACI 506.2.

B. Gunning/Nozzle Operation:

   1. Build each layer by making several passes over the working area. Thickness of each layer shall be governed by the requirement that sagging of shotcrete shall not occur. Maintain top surface of thick layers at 45-degree slope. Each layer to be covered by a succeeding layer shall be allowed to take its initial set.

2. Laitance, loose material, and rebound shall be removed by air-jetting. Laitance that has taken a final set shall be removed by sandblasting and the surface cleaned with air-water jet. All layers to be shot shall be damp.
3. Unless otherwise permitted, begin application at the lowest elevation.
4. Do not trowel or finish initial layers in any way.

C. Rebound: Any rebound or accumulated loose aggregate shall be removed from the surface to be covered prior to placing succeeding layers. Rebound shall not be salvaged for reuse.

D. Construction Joints: Unfinished work shall not stand more than 30 minutes unless construction joints are provided. Construction joints shall be designed and provided as specified in Section 03 30 00, Cast-In-Place Concrete. Entire joint surface shall be cleaned, roughened, and dampened prior to application of additional shotcrete.

E. Finishing: Bring shotcrete layers to within 1/4 inch of final finished surface. When surface has taken its initial set, trim excess material with a sharp-edge cutting screed. Remove ground wires. Provide flash coat or finish coat as required for the final finish. Final finish shall be as specified in the Construction Specifications or elsewhere in the Contract requirements. Comply with applicable requirements of ACI 506.2.

3.4 CURING

A. Immediately following shotcrete finishing, surfaces shall be cured for not less than 7 days using an approved curing method as specified in ACI 506.2.

3.5 CLEANING

A. Clean surfaces and work site of rebound and waste materials, and remove from the site.

3.6 FIELD QUALITY CONTROL

A. Requirements: All tests, cores, and core tests shall be performed by an independent testing laboratory or agency employed by the Contractor.

B. Inspections:

1. Visual inspection by the Contractor’s engineer shall be performed of the shotcrete work, including equipment, materials, forms, reinforcement, embedded items, placement, finishing, curing, and protection of the finished product.
2. Surfaces may be sounded with a hammer to locate drummy or hollow-sounding areas resulting from rebound pockets or lack of bond. Such hollow-sounding areas, voids, sags, and other defects shall be carefully cut out and replaced.

C. Quality Control Tests:

1. Test Panels:
   a. From each 50 cubic yards of each shotcrete mix, or fraction thereof, applied in the work by each crew in each shooting position, fabricate four unreinforced test panels, each 18-inches square and 7-1/2 inches thick. Fabricate test panels in accordance with ACI 506.2. Properly cure test panels in accordance with ASTM C31 and ACI 506.2.

b. Test panels will be visually examined by the Contractor's engineer, and shall be tested by an independent testing laboratory or agency employed by the Contractor. Strength of shotcrete shall be considered acceptable when the average of all strength tests, as well as the average of three consecutive strength tests, representing each shotcrete mix is equal to at least 85 percent of the specified design strength and no individual strength test is less than 75 percent of the design strength. Strength tests shall be performed in accordance with ASTM C42.

c. The Contractor shall obtain adjustments to the mix proportions, requalification of the shotcreting crew, or additional curing of the shotcrete if either of the following conditions occur:

1) The average 7-day strength of any two specimens for the shotcrete mix is less than 70 percent of the specified 28-day strength, (3 days for High-Early Strength Design); or

2) The average 28-day strength of any two specimens for the shotcrete mix is less than 100 percent of the specified 28-day strength.

2. Test Cores:

a. Should the test panels indicate that shotcrete not meeting the specified requirements has been produced, the Contractor shall test cores, taken from the areas represented by the test panels, to determine compliance of the in-place shotcrete with the specified requirements.

b. Test cores shall be 3 inches minimum diameters, obtained and tested in accordance with ASTM C42.

c. Three cores shall be taken for each determination of in-place strength. Shotcrete in the area represented by the core tests shall be considered structurally adequate if the average of the three cores is equal to at least 85 percent of the specified design strength and no single core is less than 75 percent of the design strength. Locations represented by erratic core strengths shall be retested.

d. Fill core holes with low-slump concrete or mortar of same mix design as the placed shotcrete.

END OF SECTION

SECTION 03 40 00

PRECAST CONCRETE

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Precast concrete members and components.

B. Anchors, Lift Devices, and Accessories.

C. Installation and erection.

1.2 RELATED SECTIONS

A. Portland cement concrete is specified in Section 03 05 15, Portland Cement Concrete.

B. Precast, prestressed concrete is specified in Section 03 05 18, Prestressed Concrete.

C. Concrete formwork is specified in Section 03 11 00, Concrete Forming.

D. Reinforcing steel for concrete is specified in Section 03 20 00, Concrete Reinforcing.

E. Steel supporting brackets and plates are specified in Section 05 50 00, Metal Fabrications.

F. Precast concrete structures for utilities are specified in Section 33 05 16, Utility Structures.

1.3 REFERENCE STANDARDS

A. American Concrete Institute (ACI):

1. ACI 301 Specifications for Structural Concrete
2. ACI 318 Building Code Requirements for Structural Concrete and Commentary

B. ASTM International (ASTM):

1. ASTM A123 Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
2. ASTM A153 Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
3. ASTM C494 Standard Specification for Chemical Admixtures for Concrete
4. ASTM C618 Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Portland Cement Concrete
5. ASTM C1017 Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete

C. American Welding Society (AWS):

1. AWS D1.1 Structural Welding Code – Steel
2. AWS D1.4 Structural Welding Code - Reinforcing Steel

3. AWS D1.8 Structural Welding Code – Seismic Supplement

D. Precast/Prestressed Concrete Institute (PCI):

1. PCI MNL116 Quality Control for Plants and Production of Structural Precast Concrete Products
2. PCI MNL 117 Quality Control for Plants and Production of Architectural Precast Concrete Products
3. PCI MNL 122 Architectural Precast Concrete

1.4 DEFINITIONS

A. Regular Precast: Acoustical barrier panels and such other members or components as indicated.

B. Architectural Precast: Stair components, windscreen and bench components, bollards precast concrete bases, and such other architectural precast members or components as indicated.

1.5 SUBMITTALS

A. Shop Drawings: Submit shop drawings showing the following:

1. Detailed drawings of panels, members, and components, showing dimensions and sections of each.
2. Quantities, dimensions, and locations of sleeves, anchors, brackets, inserts, reglets, reinforcing steel, lift devices, accessories, and methods of securing same in forms.
3. Casting, consolidating, and finishing procedures.

B. Product Data: Submit manufacturer's product data of manufactured products and accessories. Include manufacturer's detailed drawings and dimensions when applicable.

C. Samples: Obtain the Contracting Officer’s acceptance of the following samples:

1. For precast concrete to be exposed in the finished work to public view, submit form facing material, 12 inches by 12 inches or larger in size as appropriate.
2. For precast concrete to receive sandblasted or other surface finish, submit sample of concrete with specified finish, 12 inches by 12 inches or larger in size as appropriate.

D. Certificates:

1. Submit evidence of current plant certification under the PCI Plant Certification Program.
2. Submit manufacturers' certifications of compliance for materials as required by PCI MNL117 or PCI MNL-116, as appropriate, and accepted by the Contracting Officer.
3. For welders, furnish welding certificates or affidavits attesting to the welders' qualifications to perform the indicated and specified welding.

1.6 QUALITY ASSURANCE

A. Qualifications of Fabricator:

1. Fabricator of precast concrete products shall be an active and approved participant in the PCI Plant Certification Program.

2. Precast concrete work shall be produced in a plant or production facility by a fabricator who has been regularly and continuously engaged in the manufacture of precast concrete products.
3. Fabricator shall have sufficient production capacity to produce the required units without causing delay in the work.

B. Qualifications of Welders: Welders shall be prequalified in accordance with AWS D1.1 or AWS D1.4, as applicable to the work.

C. Welding shall comply with AWS 1.8.

D. Tolerances: Fabricate and erect precast concrete members within the tolerances recommended in PCI MNL-117 or PCI MNL-116, as appropriate.

E. Mock-Ups: At the casting plant, construct a minimum of five sample panels or units of the actual item or section of item, not less than 3 feet by 4 feet in size, that shows the features, finish, and color of concrete surfaces exposed to public view. A minimum of two samples of the mock-up will be selected by the Contracting Officer as control samples to establish a range of color or shade and texture that will be acceptable. The mock-ups shall be submitted for review and acceptance by the Contracting Officer prior to starting production.

F. Control Samples: All finishes and colors shall match the Contracting Officer's control samples. Control samples require the Contracting Officer's acceptance before they may be used as a standard.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Transport, handle, and store units in a manner that will prevent damage to the members.

B. If storage of precast units at the site is necessary, store units in a manner that will prevent cracking, distortion, staining, or other damage. Support members at their respective designed bearing support points.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Reinforcing Steel: Comply with applicable requirements of Section 03 20 00, Concrete Reinforcing.

B. Portland Cement Concrete:

1. Comply with applicable requirements of Section 03 05 15, Portland Cement Concrete. Provide class of concrete as indicated.
2. When a dense, high-strength concrete is required, as for stair treads, a fly ash or pozzolanic admixture (ASTM C618), not to exceed 10 percent of the weight of the cement, may be introduced in the mix along with the required plasticizer (ASTM C1017) or water-reducing admixtures (ASTM C494, Type F or Type G).
3. Provide white Portland cement and crushed white aggregate where required to achieve colored concrete matching the accepted control sample.

4. Coloring material for colored concrete shall be a standard commercial brand of chemically inert mineral oxide coloring material accurately measured by weight in a definite manner for each batch of concrete to produce a consistently even color. Material shall be readily dispersable in water. Color will be as selected by the Contracting Officer from samples prepared and submitted by the Contractor.

C. Anchors, Lift Devices, and Accessories: Provide concrete inserts, reglets, anchors, brackets, and fasteners as indicated or required for fabrication and installation work. All items shall be zinc-coated or galvanized in accordance with ASTM A153 or ASTM A123, as applicable. Select the lift devices, and shall be responsible for their performance and damage resulting from the use of faulty or inferior devices. Lift devices shall not be visible on exposed faces of precast members.

2.2 FABRICATION

A. Requirements and Standards:

1. Manufacture precast concrete units in accordance with PCI MNL-117, PCI MNL-122, and applicable requirements of ACI 318/318R, Chapter 16.
2. Forms shall be accurately constructed to produce members to dimension, shape, configuration, and profile indicated. When not otherwise indicated, construct forms to produce smooth concrete.
3. Concrete reinforcement, lifting reinforcement, and concrete inserts and anchorage devices shall be placed and secured against movement as required.
4. Concrete shall be placed and consolidated to shape, configuration, and dimensions indicated.
5. Members shall be moist cured in accordance with curing requirements specified in PCI MNL-117. Minimum curing period for combined initial curing and secondary curing shall be seven days or until the specified strength of concrete is attained.

B. Finishes:

1. Provide finishes for exposed concrete matching accepted samples and mock-ups and the accepted control samples.
2. When sandblasted finish is indicated, provide "sandblast finish" as specified in ACI 301. Degree of sandblasting shall be as required to provide surface finish matching the accepted control sample.
3. For items not exposed to public view, provide "smooth form finish" as specified in Section 03 35 00, Concrete Finishing.

C. Markings: Provide permanent markings in precast units to identify pick-up points and orientation in the structure, conforming to the markings indicated on shop drawings. Imprint the date of casting on each precast unit where it will not show in the finished structure.

D. Prior to shipment, thoroughly clean all surfaces exposed to public view and the faces of all joints of laitance, bond-breaking compound, and other foreign material by light sand blasting.

2.3 SOURCE QUALITY CONTROL

A. The Contractor-employed independent testing laboratory or agency shall perform inspections and tests required to verify compliance with these Specifications.

B. Concrete shall be tested for compressive strength as specified in Section 03 05 15, Portland Cement Concrete.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine supporting structure and the conditions under which the precast concrete units are to be erected and installed. Verify the locations of anchors to pre-determine the accuracy of the installation of each member.

3.2 ERECTION/INSTALLATION

A. Transport and erect precast concrete units in accordance with PCI MNL-117 and as specified herein.

B. Erect precast concrete units and accurately install in place with mechanical hoisting equipment more than adequate for the loads.

C. Maintain precast concrete unit in upright position at all times. Handle unit only by indicated lifting devices or cushioned pads, and in a manner that will not overstress or damage the unit.

D. Erect precast concrete units in accordance with indicated erection tolerances. Comply with erection sequences indicated. Position units to avoid eccentric application of forces, and make complete and uniform contact with bearing surfaces.

E. Provide anchorage and attachment welding and bolting, as indicated, in accordance with PCI MNL-117, Division VI.

F. At completion, units shall be plumb, level, and square, true to line, with angles and edges parallel with related building lines.

3.3 REPAIR

A. Upon arrival at the delivery site, inspect each unit. If damage has occurred during shipment that will impair the structural function of the unit, the reject unit. Replace a rejected unit with an approved unit. Repair non-structural surface defects in accordance with Section 03 35 00, Concrete Finishing. Surfaces exposed to public view sustaining damage to a contiguous area of more than 25 square feet or more than 25 percent of the exposed surface, whichever is less, shall be repaired by a method accepted by the Contracting Officer. If the damage cannot be repaired to the Contracting Officer's satisfaction, the unit shall be rejected. Replace a rejected unit with an approved unit.

END OF SECTION

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SECTION 03 43 00

PRECAST CONCRETE SEGMENTAL CONSTRUCTION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Fabrication.

B. Erection.

C. Epoxy Jointing of Precast Segments.

D. Packed Mortar Joints for Joints, Bearings, or Setting Pier Shaft Segments.

E. Watertight Decks.

F. Stressing of Tendons.

G. Grouting of Ducts.

H. Forming and Repair of Holes and Blockouts.

I. Protection of Post-Tensioning Anchorages.

1.2 DESCRIPTION.

A. This Section includes fabrication, storage, transportation, and erection of precast structural concrete superstructure and substructure segments on a prepared foundation, to the established lines and grades, and in accordance with the design, dimensions, and details shown on the Construction Drawings.

B. Use methods and procedures that protect the public with from construction/erection activities and falsework placed over or adjacent to traveled roadways, navigational or recreational waterways, or existing commercial, industrial or other facility.

1.3 RELATED SECTIONS:

A. Section 03 05 15, Portland Cement Concrete.

B. Section 03 05 18, Prestressed Concrete.

C. Section 03 20 00, Concrete Reinforcing.

D. Section 03 35 00, Concrete Finishing.

1.4 DEFINITIONS

A. The following definitions apply to segmental bridge construction:

B. Balanced Cantilever (Erection): Segments are sequentially erected, alternately on either side of the pier in cantilever, to a point where a closure is cast in place.

C. Camber: The amount by which the concrete profile at casting time must differ from the theoretical geometric profile grade to compensate for all structural dead load, post-tensioning, and long-term and time-dependent deformations (creep and shrinkage), including all intermediate erection stages and effects.

D. Casting Cell: A special formwork arrangement that usually consists of a fixed vertical bulkhead of the cross-section shape at one end and adjustable soffit, side and core forms all designed and assembled into a machine for making a single superstructure segment. A casting cell for a substructure pier shaft segment consists of exterior and interior side forms and a soffit form of the cross-section shape.

E. Casting Curve: The curve of casting geometry that has to be followed in the casting cell or bed to achieve the theoretical bridge profile and alignment, after all final structural and time-dependent (creep and shrinkage) deformations have taken place. The casting curve is a combination of the theoretical bridge geometrical profile grade, alignment, and camber.

F. Erection Elevation: The elevation at which a segment is set in the structure at the time it is erected. (Profile grade corrected by the amount of deflection calculated to occur from that stage onward.)

G. Long Line Casting: Casting segments on a casting bed of sufficient length to permit the cumulative casting of segments for the entire length of a span or cantilever between field closure pours, without repositioning the segments on the casting bed. With this method, the first segment is cast between bulkheads and successive segments are cast between a movable bulkhead on one end and the previously cast segment on the other.

H. Match Cast: A precast concrete fabrication process whereby a segment is cast against the preceding segment, producing a matching interface that permits the re-establishment of the cast geometry at erection time. Match casting is accomplished by either the short line or long line casting method.

I. Progressive Cantilever (Erection): Segments are erected progressively in cantilever, in one direction, from one pier to the next, using temporary intermediate piers or other systems as required to support the advancing cantilever between piers.

J. Segment: A modular section of the superstructure and substructure consisting of a certain cross-section shape and length, as detailed on the Construction Drawings.

K. Short Line Casting: Casting segments one at a time in a casting cell, between a bulkhead at one end and a previously cast segment at the other. The first segment is cast between the bulkhead and another temporary bulkhead.

L. Span by Span (Erection): Placing a specified number of segments on a temporary support system, aligned and post-tensioned longitudinally to form a completed span of the superstructure. Also placing single full span girders on bearings resting on final supports.

M. Wet Joint System: Where segments are made in a casting cell between two bulkheads and are not match cast, the segments are then erected in the superstructure with a narrow cast-in-place joint between each segment. (During erection, all the segments of a span or multiple spans are

supported by falsework, truss, or another technique until the joints have gained strength and the longitudinal post-tensioning is installed to make them self supporting.)

1.5 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO):

1. Load and Resistance Factor Design (LRFD) Bridge Design Specifications
2. Load and Resistance Factor Design (LRFD) Bridge Construction Specifications

B. ASTM International (ASTM):

1. ASTM A240 Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
2. ASTM C39 Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
3. ASTM C881 Specification for Epoxy-Resin-Base Bonding Systems for Concrete
4. ASTM C882 Test Method for Bond Strength of Epoxy-Resin Systems Used With Concrete By Slant Shear
5. ASTM D695 Test Method for Compressive Properties of Rigid Plastics

C. American Welding Society (AWS):

1. ANSI/AWS D1.4 Structural Welding Code – Reinforcing Steel

D. State of California Department of Transportation (Caltrans) Standard Specifications:

1. Section 51-4 Precast Concrete Members

1.6 SUBMITTALS

A. Information Required: Submit detailed shop drawings, calculations, and manuals that include but are not necessarily limited to the following:

1. A schedule of the timing and sequence of segment casting and erection, including the sequence of making cast-in-place closures and continuity between spans.
2. Details of the disposition and use of special erection equipment, falsework, and temporary supports. Include all loads or reactions from such equipment applied to the structure during erection, and the sequences and timings of these effects in accordance with the erection schedule.
3. Details of the forms and casting cells for the manufacture of the segments.
4. Layout of the casting yard showing operational features, casting cells, rebar fabrication and material storage areas, movable rain and sun sheds, geometry control stations, and segment handling and storage facilities.
5. Calculations and details for lifting, storage, or stacking of the segments.
6. Details of inserts or lifting holes, including necessary localized strengthening and the materials and methods to fill and finish such holes.
7. Details and calculations for localized strengthening for concentrated supports, loads, or reactions from special erection equipment placed in locations not already allowed for in the Construction Drawings.
8. Details and a complete description of post-tensioning hardware components and other embedments to be cast into the segments.

9. To accommodate variations from the views and dimensions shown on the Construction Drawings, provide fully and accurately dimensioned views showing the revised geometry of the segment. Include projections, recesses, notches, opening, and blockouts with clear and concise cross-reference to the appropriate Construction Drawings to which the variations apply.
10. Where variations are made to segment geometry and dimensions, appropriate details of changes to reinforcing that clearly show the size, spacing and location. Include special reinforcing required but not shown on the Construction Drawings, with clear and concise cross-reference to the appropriate Construction Drawings to which the variations apply.
11. The size, type, and components of the post-tensioning system to be used. The duct type, size, and support spacing. Locate all relevant details and grout inlets/outlets. The method of maintaining the position and alignment of duct couplers at the segment joints. Ensure all post-tensioning alignments are in accordance with the Construction Drawings, unless the Contractor’s proposed variations require changes, in which case horizontal and vertical profiles will be fully detailed.
12. Details of and supporting calculations for modifications to reinforcement at anchorages, deviation saddles, and diaphragms made necessary for accommodating the elected post-tensioning system hardware.
13. Casting curves and erection elevations, prepared in accordance with chosen construction methods, sequence and schedule. In this respect, the construction methods, sequence, and schedule include but are not limited to: Contractor-adopted general construction techniques; erection equipment and its deployment and effect on the structure; introduction or removal of temporary supports, falsework, and closure devices; their deployment and effect on the structure; the order (sequence) in which all casting, construction methods, and step-by-step erection operations are executed, including post-tensioning; and the timing (schedule) of all such operations, with respect to the maturity of the concrete and affect thereon.
14. A manual for the casting and geometry control of the segments, in accordance with the information provided in the Contract Documents or as required by these Specifications. (This is referred to as the “Casting Manual” under the Article entitled “Fabrication” herein.)
15. A manual for detailed step-by-step erection of the segments, including all intermediate procedures relating to erection equipment, falsework, movement of equipment, support jacking, stressing of temporary post-tensioning bars, closure operations (including partial stressing across the closure during concrete curing), main post-tensioning tendon sequences, stressing loads and elongations, erection elevations, and a method for field survey and alignment control for setting initial and subsequent segments and other relevant operations. (This is referred to as the “Erection Manual.”)
16. Method of mixing and placing grout; equipment capacity; and mix design.
17. The volume of concrete, the weight of reinforcement and weight of post-tensioning in each precast segment, and totals of these for both the superstructure and substructure summarized and tabulated on the shop drawings.
18. In general, revisions to materials, components, erection methods, or erection sequencing indicated on the Construction Drawings and to previously approved shop drawings shall require submittals prepared and sealed by the Contractor’s Engineer of Record for the Contracting Officer acceptance .

B. In regard to casting operations, submit documentation of experience and qualifications of the supervisory and instrument operating personnel, particularly with regard to the observational precision required.

C. Record of Jointing: Submit on a weekly basis.

1.7 QUALITY ASSURANCE

A. Use experienced personnel to operate the instruments and supervise the casting operation. Prior to the commencement of casting, obtain the Contractor's engineer's approval of the experience and qualifications of the supervisory and instrument operating personnel, particularly with regard to the observational precision required.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Handle segments with care to prevent damage. Handle segments using only the devices shown on the shop drawings for this purpose. Store all precast segments level in the upright position. Firmly support all precast segments for storage and shipment on an approved three-point bearing system that does not introduce a twist under self weight. Do not stack superstructure segments one upon another unless indicated in the approved shop drawings.

B. Prior to shipment, the thoroughly inspect each segment for damage. Prior to shipment, thoroughly clean the faces of all joints of laitance, bond-breaking compound, and other foreign material by light sand blasting. Make no repairs of minor spalls or chipped areas on the joint surfaces until after erection of the segment. Upon arrival at the delivery site, re-inspect each segment. If damage has occurred during shipment that will impair the structural function of the segment, the segment shall be rejected. Replace a rejected segment with an approved segment at no cost to the Authority. Repair non-structural surface defects in accordance with Section 03 35 00, Concrete Finishing. Surfaces exposed to public view sustaining damage to a contiguous area of more than 25 square feet or more than 25 percent of the exposed surface, whichever is less, shall be repaired by a method approved by the Contractor's engineer.

C. Provide firm support at bearing locations noted herein above. Fully secure the segments against shifting during transport. Provide a storage area of suitable stability for the segments, to prevent differential settlement of the segment supports during the entire storage period.

PART 2 - PRODUCTS

2.1 CONCRETE

A. Use concrete as specified in Section 03 05 15, Portland Cement Concrete, except as specifically modified herein. Gradation for coarse aggregate utilized in the concrete for segments will be such that 100 percent passes a 1-inch sieve. Use No. 67 course aggregate in lieu of the grade specified in Section 03 05 15, Portland Cement Concrete, to meet this gradation requirement. Screenings are not allowed as a substitute for silica sand for use in concrete for precast superstructure segments.

2.2 REINFORCING STEEL

A. Use reinforcing steel that meets the requirements of Section 03 20 00, Concrete Reinforcing.

2.3 POST-TENSIONING SYSTEMS

A. Use post-tensioning hardware components meeting the requirements of Section 03 05 18, Prestressed Concrete. Components are not interchangeable and shall comply with the details of the approved shop drawings.

2.4 EPOXY BONDING SYSTEMS

A. Use only epoxy bonding agents for match-cast joints between precast segments in accordance with the following:

B. General: Use only epoxy bonding agents for match-cast joints between precast segments that are thermosetting 100-percent solid compositions and do not contain solvent or non-reactive organic ingredients, except for pigment required for coloring and meeting the requirements of ASTM C881, Type VI Grade 3 as modified herein below. Use epoxy bonding agents composed of two components – a resin and a hardener – with each component distinctly pigmented so that mixing produces a third color similar to the concrete in the segments. Epoxy bonding agents shall be insensitive to damp conditions during application and, after curing, shall exhibit high bonding strength to cured concrete, good water resistivity, low creep characteristics, and tensile strength greater than the concrete.

C. Packaging, Identification and Use: Use only components packaged in two parts, in sealed containers, proportioned in the proper reacting ratio, ready for combining and mixing in accordance with the manufacturer's instructions. Each container shall bear a label and stamp designating the manufacturer's name, brand name, the component type (resin or hardener), the range of substrate (surface of concrete) temperature over which the application is suitable, material classification, the date of formulation, the shelf life of the material, and the manufacturer's lot number. Provide instructions furnished by the manufacturer for safe storage, handling, mixing, and application of the material. Do not use materials from containers that are damaged or have been previously opened. Combining of epoxy bonding components from bulk supplies will not be permitted. Only full packets of components will be mixed.

D. Classification of Epoxy Material: Epoxy bonding agents that remain workable for a short open time (approximately 1 hour) are referred to herein as "normal-set epoxy." Epoxy bonding agents that remain workable over an extended open time (approximately 8 hours) are referred to herein as "slow-set epoxy." Select the appropriate epoxy material based on the job requirements as either normal or slow-set epoxy, within the formulation temperature range based on the substrate temperature.

E. Formulation for Temperature Range: Epoxy bonding agents shall be formulated to provide application temperature ranges that are suitable for erection of match-cast segments with substrate temperatures between 40 and 115 degrees Fahrenheit, with a minimum of at least two but preferably three formulations dividing the range into approximately equal subranges that overlap by at least 5 degrees Fahrenheit.

F. Physical Requirements:

1. General: Epoxy bonding agents proportioned as designated by the manufacturer and mixed in accordance with the manufacturer's recommendations shall meet the requirements of ASTM C881. For the properties listed herein below, modify the ASTM test procedures as noted. Components of the epoxy bonding agent shall be conditioned to the temperature at which testing is to be completed prior to mixing the test specimen.

2. Contact Time (Open Time) and Contact Strength:
    a. The contact time (open time) of the mixed epoxy bonding agent shall be:
        1) Normal-Set Epoxy: 60 minutes minimum
        2) Slow-Set Epoxy: 8 hours minimum
    b. The herein above contact time (open time) will be deemed acceptable if a slant cylinder test specimen, prepared and tested in accordance with the conditions below, sustains the following stress (contact strength) on the slant plane calculated as the axial (vertical) load divided by the area of the slant ellipse:
        1) Normal-Set Epoxy: 1,000 (psi) at 48 hours after joining
        2) Slow-Set Epoxy: 1,000 psi at 14 days after joining
    c. Slant Cylinder Test: The cement mortar/concrete material for the slant cylinder test shall have a compressive strength of at least 4,500 pounds per square inch (psi) at 28 days when tested to ASTM C39. The slant cylinder test procedure shall be in accordance with ASTM C882 with the following modifications:
        1) Joining of the sloped surfaces shall be delayed for the following period of time, measured from the time the epoxy was mixed.
        Normal-Set Epoxy: 60 minutes.
        Slow-Set Epoxy: 8 hours.
        2) During the period between mixing the epoxy and joining the sloped surfaces, the specimens will be uncovered and maintained at the maximum temperature of the application range for the formulation tested.
        3) Assemble the specimens together and cure at the maximum temperature of the formulation range (48 hours for normal set and 14 days for slow-set epoxies) prior to testing.
        4) For slow-set epoxy, an additional test specimen shall be made and tested to failure at 24 hours. The formulation of the slow-set epoxy is acceptable only if the epoxy bonding agent exhibits a brittle break.

3. Compressive Yield Strength: The compressive yield strength of the epoxy bonding agent shall be in accordance with ASTM C881 when tested using ASTM Method D695 with the following conditions:
    a. Epoxy bonding agent shall be poured into the mold for forming specimens within 10 minutes after starting mixing of the components.
    b. The specimens shall be cured at the minimum temperature of the formulation range for a period of 24 hours.

4. Bond Strength: Bond strength shall be in accordance with ASTM C881 and the test shall be conducted on a slant cylinder according to ASTM C882 with the following modifications.
    a. The test cylinder of concrete shall have a compressive strength of at least 6,000 psi at 7 days age.
    b. The specimens shall be prepared as defined in Article entitled “Epoxy Bonding Systems” under Paragraph entitled “Slant Cylinder Test” herein.

2.5 BOND BREAKER FOR ABUTTING SURFACE OF THE MATCH-CAST SEGMENT

A. Bond breaker shall consist of flax soap and talc, or other material approved by the Contractor’s engineer. Use a soap and talc mixture consisting of five parts flax soap to one part talc. The Contractor’s acceptance of a material other than soap and talc shall be based in demonstration on a large specimen consisting of a precast piece and a new-cast piece with a contact facial area of at least 4 square feet.

2.6 FABRICATION

A. General: Ensure that all materials, details, and procedures are as specified herein, as noted on the Construction Drawings, or approved submittals. Do not begin casting segments until the the relevant shop drawings, calculations, casting manuals, concrete forms and concreting operations, and post-tensioning system components and layout if different from that on the Construction Drawings are approved. (Approval of post-tensioning stressing elongations and forces for field erection operations is not required at this stage, but required prior to erection.) To use wet joints to join cantilevers or for corrective measures, obtain the Contractor's engineer's written approval.

B. Erection marks: Give each segment an erection mark indicating its location, orientation, and order in the erection sequence. Match-mark abutting edges of adjacent segments. Show erection marks on the erection plans or in the Erection Manual. Refer to additional applicable requirements specified in Section 03 05 18, Prestressed Concrete.

C. When welding reinforcing steel, meet the requirements of the American AWS D1.4. If welded reinforcing grillages are proposed, obtain Contractor's engineer's written approval prior to their fabrication. Field welding of reinforcing steel is not allowed.

D. Forms: Design and fabricate forms in accordance with Standard Specification 03 11 00, Concrete Forming – General – Form Fabrication. Form all exposed formed surfaces of each element of the structure with the same material to produce similar concrete surface textures, color, and appearance. Obtain approval of forms in accordance with the Contractor's Quality Management Plan prior to initiating casting operations. Build the details shown on the Construction Drawings as amended by approved shop drawings into the forms. Repair worn, damaged, or otherwise unacceptable forms and obtain approval in accordance with the Contractor's Quality Management Plan before casting a segment.

1. Form tolerances: Where sections of forms are joined, ensure that offsets in flat surfaces do not exceed 1/16 inch and that offsets with corners and bends do not exceed 1/8 inch. Ensure that all joints in the forms and contact points with bulkheads and existing segments have good fitting seals to prevent loss of fine material and cement grout.
2. Check and inspect forms on a regular weekly basis to ensure proper alignment and geometric accuracy. Do not use forms that fail to meet the specified casting tolerances until such corrections are made to produce segments within the specified tolerances.
3. Blockouts: Use a small blockout at all locations where an external tendon enters or exits the face of the concrete at deviation blocks and diaphragms, except at anchorage locations. The blockout will be approximately 2 inches larger in diameter or overall dimensions than the tendon duct and have a depth equal to at least the minimum prescribed concrete cover dimension shown in the Construction Drawings.

E. Casting Control (Geometry): Before commencing the casting operation, submit the proposed method of geometry control for all segment casting operations and obtain the Contractor's engineer's approval. This submittal shall be in the form of a Casting Manual and include information:

1. All measuring equipment, procedures, and the location of control points to be established on each segment.
2. The location and values of all permanent benchmarks and reference points in the precasting yard.

3. A geometry control procedure for vertical and horizontal alignment control for the precasting of segments including survey controls and procedures, observations, checks, computational and graphical methods, and correction techniques.
4. Casting curves that include the theoretical geometric horizontal alignment, profile grade, and superelevation appropriately combined with the camber.
5. Ensure that the Casting Manual covers all necessary geometry control operations and is compatible with the chosen methods of casting and erection, including erection survey, elevation, and alignment control. Prepare the manual as specified in this Section.
6. Do not begin casting without the Contractor’s engineer’s approval of the geometry control method.
7. In the precasting yard, use instruments for geometry control that are mounted on a permanent platform of sufficient height to sight on all control points. In addition, establish and maintain permanent benchmarks and reference points throughout the casting operations.
8. During casting, make all corrections required in the geometry of the segments from the control points established on each segment.
9. With a match-cast system, after casting and before bond breaking to separate the segments, re-check the position of the new-cast and match-cast segments. If positions are not as desired, make corrections in the next segment. In general and unless otherwise accepted by the Contracting Officer, make observations on the geometry control reference hardware cast into the segments (e.g., elevation bolts, alignment offsets, and lengths) to a precision of ±0.001 foot.
10. During casting operations, produce and maintain on a daily basis a graphical plot of the vertical and horizontal “as-cast” alignments along each vertical and horizontal control line to an exaggerated scale in order to clearly highlight variations. Depict these against the theoretical geometric vertical and horizontal alignment casting curves on a continuous layout of an entire unit of the bridge between expansion joints. Maintain this plot in good condition so that it may be used and referenced during erection.
11. Keep all geometry control hardware cast into segments (e.g., elevation bolts and alignment hairpins) in place during erection for reference and checking purposes. Remove the hardware after completion of erection of the unit in the bridge between expansion joints.

F. Preparation for Match Casting: When match casting is used, take great care in positioning the match-cast (previously cast) segment in relation to the segment to be cast. Ensure that the match-cast segment is not twisted. Ensure that all materials to be embedded in the concrete of the new-cast segment are properly positioned and supported, in order to maintain their position and withstand concrete placement and consolidation without damage. Make provisions for all projections, recesses, notches, openings, and block-outs in accordance with the Construction Drawings and approved shop drawings. Cover the abutting surface of the match-cast segment with a thin film of bond breaker.

G. Embedded Items:

1. General: Embedded items shall be in accordance with these Specifications for prestressed and post-tensioned construction and the requirements herein.
2. Embedded Post-Tensioning Ducts: Ensure that embedded ducts for post-tensioning tendons and bars are positioned accurately to their required alignment. Properly fabricate and identify all ducts so that proper positioning is ensured and can be verified after casting. Utilize positive methods to ensure that ducts will not be displaced or damaged during concrete placement and consolidation. Adequately secure all embedded post-tensioning ducts to the reinforcement cage at intervals not exceeding 30 inches for steel pipes and 24

inches for plastic ducts (small ducts and very flexible ducts may require closer supports). Auxiliary ties and support bars needed for these purposes will be considered incidental and at no extra cost to the Contract. Ensure that auxiliary ties and support bars do not violate concrete cover requirements. After installation in the forms, ensure that the ends of the ducts are sealed at all times to prevent entry of water, debris, and fine material. Following each pour of concrete, demonstrate that all empty ducts are free of water, unobstructed, and undamaged. Immediately prior to installation of the prestressing steel, demonstrate to the Contractor's engineer's satisfaction that all ducts are unobstructed and free of water and debris.

3. Anchor Plates and Castings: Prior to placing concrete in the forms, fix all tendon anchor plates and anchor castings in their respective position in the forms, connected to their duct and sealed to prevent mortar intrusion. Ensure that anchor plates and castings are rigidly fixed in the forms to maintain their correct alignment and position during concrete placement and consolidation.
4. Reinforcing Steel: Fabricate and place reinforcing steel in accordance with the Construction Drawings or as superseded by the approved shop drawings, and as required herein. Do not cut out or remove reinforcing steel to permit proper alignment of post-tensioning ducts. Replace bars that cannot be fabricated to clear the ducts by additional bars with adequate lap lengths, and submit the details to the Contractor's engineer for approval. In the plane of the reinforcement parallel to the nearest surface of the concrete, ensure that bars do not vary from plan placement by more than 1 inch or by more than 1/8 of the spacing between bars, whichever is less. In the direction perpendicular to this plane of reinforcement, ensure that bars do not vary from plan placement by more than 1/4 inch. The top and bottom cover of reinforcing steel shall be within 1/4 inch of the cover dimensioned on the Construction Drawings. The edge cover of the reinforcing steel shall be within 1 inch of the cover dimensioned on the Construction Drawings.

H. Concrete Placement, Consolidation and Finishing:

1. General: Do not deposit concrete into the forms until the entire set-up of the forms, reinforcement, ducts, anchorages, and embedded items have been thoroughly inspected and checked. Do not place concrete until the herein above items have been properly inspected and checked; that the rate of producing and placing the concrete will be sufficient to complete the casting and finishing operations within the scheduled time; that experienced concrete finishers are available where required for finish work; and that all necessary finishing tools and equipment are on hand at the work site and in satisfactory condition for use. During conveying and placement, protect concrete against undue drying or rise in temperature and inclement weather.
2. Concrete Placement Equipment: Use concrete placement equipment of a size and design that permits placing concrete within the specified time. Clean all equipment at the end of each operation or workday and just prior to reuse, re-check the equipment and clean off hardened concrete and foreign materials.
3. Concrete Placement Sequence:
   a. Superstructure Box Segments: First place concrete in the central portion of the bottom slab between the inside edges of the internal web forms, leaving a narrow gap of 6 to 12 inches for inspection and consolidation of the bottom corners when the next load is placed in the webs. Then place the concrete in the bottom corners of each web, to connect and consolidate with the concrete already placed in the bottom slab. Then place concrete in the remainder of the webs, in lifts not exceeding 24 inches at a time, up to the top of the webs but not into the slab over the webs. Place

concrete in the top slab in the outer wing and mid-slab regions between webs before placing, completing, and consolidating zones over the top of the webs.

b. Substructure and Pier Shaft Segments: Cast precast pier shaft segments vertically. Place the concrete in uniform lifts of approximately 24 to 36 inches and consolidate well.

c. Obtain the Contractor's engineer's approval of alternative sequences to the sequence herein above, or for other precast components.

4. Concrete Placement and Consolidation: Discharge individual loads of concrete into the forms, and place and consolidate in the required locations. After discharge into the forms, do not bodily move concrete from place to place within the forms by mechanical vibrators or other similar equipment. Place and consolidate concrete with care so that post-tensioning ducts, anchorages, and other embedded items are maintained in their proper positions and are not damaged. Consolidate all concrete using approved vibrators together with other equipment necessary to perform the work as specified. Use internal vibrators with a minimum frequency of 8,000 vibrations per minute and sufficient amplitude to consolidate the concrete effectively. Provide at least two stand-by vibrators in working condition for emergency use in case of malfunction. Use external vibrators for consolidating concrete when the concrete is inaccessible for adequate consolidation by internal means. When external vibration is used, construct the forms sufficiently rigid to resist displacement or damage. Vibrate concrete in a manner that avoids displacement or damage to reinforcement, post-tensioning ducts, anchorages, and other embedded items. No construction joints are allowed within a segment, except as detailed on the Construction Drawings.

5. Finishing: Strike off the roadway surface of the segment with an approved mechanical screed operated by a self-contained power source. Furnish and use a straightedge at least 24 inches longer than the segment while finishing the concrete deck surface of superstructure box girder segments. Use a straightedge approximately parallel to the segment's centerline to strike an accurate surface between the bulkhead and the top of the match-cast segment at all positions across the segment width. Unless otherwise indicated, provide the following finishes as specified in Section 03 35 00, Concrete Finishing:

   a. Formed Surfaces: Smooth form finish

   b. Unformed Surfaces:

      1) Exposed to public view: Troweled finish

      2) Concealed from public view: Floated finish

6. Markings: Provide permanent markings in precast segment units to identify pick-up points and orientation in the structure, complying with the markings indicated on the final shop drawings.

I. Curing:

1. General: Where casting cells are intended to operate on a short (daily) cycle and it can be demonstrated to the Contractor's engineer's satisfaction that the required initial concrete strengths for removal of the forms, application of prestress, moving and handling the segments, and final concrete strength can be achieved in a timely and consistent manner, steam curing will not be required. However, take precautions to promote proper curing by methods approved by the Contractor's engineer and in accordance with Section 03 35 00, Concrete Finishing. Such precautions shall meet or exceed the following:

   a. To prevent moisture loss, cover all exposed surfaces (those not in contact with a form or match-cast segment) as soon as possible after casting with a moisture-tight

covering (wet curing blankets or other approved equal systems). Avoid spoiling the deck surface finish. Keep the cover on or within 12 inches of the deck surface.

b. Keep the moisture-tight covering substantially in place throughout succeeding operations such as geometry control survey, stripping of internal forms, wing forms, and shifting of and working with a segment in a match-cast position. Keep the concrete surface wet throughout these operations.

c. After stripping of the side and core forms, continue curing of the precast concrete by applying an AASHTO M148, Type 2 (white-pigmented) membrane curing compound as specified in Section 03 35 00, Concrete Finishing, to all exposed surfaces (including segment exterior once exposed by removal from the form). Apply an approved debonding compound to match-cast surfaces to serve both as a bond breaker and seal for curing.

d. Maintain the moisture-tight covering for at least 72 hours. As an alternative, steam curing may be used.

e. While the new-cast segment is in contact with the match-cast segment, cover the match-cast segment with curing blankets or another approved equal system, to minimize the effects of differential temperature between the segments.

2. Steam Curing: Meet the requirements of Caltrans Standard Specifications Section 90-4.03,Construction, modified by the following requirements when steam curing is used.

a. Provide a device or devices for simultaneously recording the temperature of three widely separated locations per casting cell. Locate the three temperature sensors near the top, middle, and bottom of the enclosure or as otherwise approved by the Contractor’s engineer. Identify the charts with the hours, dates, and segment number, and deliver to the Contractor’s engineer immediately after steam curing is completed, unless otherwise approved by the Contractor’s engineer.

b. Apply an approved debonding compound to match-cast surfaces to serve both as a bond breaker and seal for curing.

c. Expose match-cast segments to the same curing environment (temperature and humidity) as the new-cast segment, until the new segment reaches the required strength to allow removal of the forms.

J. Removal of Forms: Prior to removing the forms, protect the plastic concrete from adverse weather effects. Keep supporting forms in place until the concrete has reached the required strength for form removal as specified on the Construction Drawings, in this Section, or as approved by the Contractor’s engineer. Test the cylinders, made and cured in the same manner as the segment, to confirm the form release strength prior to removing form. With the Contractor’s engineer’s approval, a strength curve chart may be established to determine the time necessary for achieving the required form release strength, in accordance with these Specifications for form removal. Avoid cracking or damaging the segment when removing the forms, especially match-cast surfaces and shear keys. Notify the Contractor’s engineer of damage that occurs and repair in a manner approved by the Contractor’s engineer.

K. Age at Erection: Unless otherwise approved by the Contractor’s engineer, precast components shall be at least 14 days old prior to incorporating into the structure.

L. Tolerances:

1. General: The following tolerances apply to the fabrication of precast components:

a. Superstructure Box Segments:

1) Width of web: ±1/4 inch

2) Depth of bottom slab: ±3/16 inch
3) Depth of top slab: ±3/16 inch
4) Overall depth of segment: ±3/16 inch
5) Overall width of segment: ±1/4 inch
6) Length of segment: ±3/8 inch
7) Diaphragm dimensions: ±3/8 inch

b. Precast Box Pier Segments
1) Height (individual element): ±1/4 inch
2) Width and breadth (individual element): ±1/4 inch
3) Thickness (wall): ±1/4 inch

c. All Fabricated Segments:
1) Ends: deviation from a plane per 20 feet width ±1/4 inch per 20 feet, not to exceed 1/2 inch
2) Flat Surface: deviation from a plane ±0.025 inch per foot, not to exceed a total of 1/4-inch

2. Corrections: Control dimensions from segment to segment, including cast-in-place segments, and compensate for deviations within a single segment or series of segments so that the overall dimensions of the completed structure meet the dimensions and overall erection tolerances shown on the Construction Drawings and allowed by this Section.
3. Repairs: Repair minor breakage, spalling, or honeycomb (not over 1 inch deep) by a method approved by the Contractor's engineer. Major breakage, spalling, or honeycomb in excess of 1 inch deep is subject to the Contractor's engineer's structural review. If found to be satisfactory, repair these areas using a method approved by the Contractor's engineer. Do not perform surface finishing or repairs on the matching joint surfaces of precast segments until after final erection of the segment, except as herein noted. If more than 20 percent but less than 40 percent of the total contact surface of all shear keys in any single web is broken, spalled, or honeycombed, grind the damaged areas to produce a cylindrical depression into sound concrete to a depth and width approximately equal to the shear key dimensions. Complete necessary repairs to shear keys damaged at the casting site prior to shipping the segment to the erection site. After erection of the segments adjacent to the damaged keys and prior to erection of additional segments, carefully pack the voids left by the depressions with an epoxy mortar approved by the Contractor's engineer. With the Contractor's engineer's approval, an alternate method of repair may be used. The segment shall be rejected as unsatisfactory for use if more than 40 percent of the total contact surface of all shear keys in any single web is broken, spalled, or honeycombed. Use a Contractor's engineer-approved method to repair damaged alignment keys located in the top and bottom slabs. The segment shall be rejected as unsatisfactory for use if over 50 percent of the total contact surface of all alignment keys in any element of the slab (e.g., wing overhang, central portion between webs) is broken, spalled, or honeycombed. Remove and dispose of segments found to be unsatisfactory and not repairable after structural review and cast a new segment.

2.7 FABRICATION AND ERECTION QUALITY CONTROL

A. Test Samples: Provide additional test samples and testing for compressive strength on precast segments and field closure joints, to control construction activities and ensure adequate strength of these components at various stages of their manufacture and assembly. Make test cylinders, in accordance with Section 03 05 15, Portland Cement Concrete, cured in the same manner as the structural components to ensure adequate compressive strength has been achieved, in accordance with the Construction Drawings requirements for the following conditions:

1. Prior to release of prestressing for components that are to be pretensioned.
2. Prior to form release and moving the components to storage.
3. Prior to post-tensioning transverse tendons if the component is less than 28 days old.
4. Prior to placing a component into position in the structure and stressing of longitudinal post-tensioning tendons if the component is less than 28 days old.
5. Determine the number of cylinders in accordance with the proposed method for casting, transporting, and erecting the various components.
6. Provide the results of the compression testing of one or more test cylinders for controlling the time of execution of the various construction operations. Obtain the Contractor's engineer's approval for meeting these Specification requirements for casting, curing, and testing concrete test cylinders.

PART 3 - EXECUTION

3.1 ERECTION

A. Erection Manual: Before commencing erection operations, submit proposals for all segment erection operations to the Contractor's engineer for approval. This submittal shall be in the form of an Erection Manual and shall include the following information, at minimum:

1. A detailed step-by-step sequence for erection of each segment, including all intermediate procedures relating to erection equipment, temporary and permanent post-tensioning, and making closures between spans and cantilevers.
2. Positioning, use, and sequencing of falsework; and jacking and releasing of falsework, temporary towers, and closure devices.
3. Positioning, use, and sequencing of erection equipment (e.g., cranes, beam, and winch devices, gantries, and trusses) including the movement, introduction and removal of supports onto or connections with the structure.
4. Detailed scheduling of all temporary and permanent post-tensioning operations and sequences in accordance with segment erection and closure operations.
5. Stressing forces and elongations for post-tensioning.
6. Sequencing of grouting operations.
7. A method for field survey control for establishing and checking erected geometry (elevations and alignments), with particular attention to setting of critical segments such as pier segments for balanced cantilever erection.
8. Other relevant operations, as required and applicable to the structure type and construction method.
9. Do not start erection without the Contractor's engineer's approval of the Erection Manual.

B. Erection Geometry Control:

1. General: Numerical or graphical methods may be used for alignment control and checking during erection. Establish the key stages for checking the erection in the Erection Manual and obtain the Contractor's engineer's review and approval. Key stages would include, for example, setting a pier segment during cantilever erection and various intermediate points during subsequent segment erection, at span closure and upon completion. Prepare a table of elevations and alignments required at each key stage of erection in accordance with the Construction Drawings, as cast geometry, camber, and erection elevations for establishing erection controls and submit to the Contractor's engineer for approval. Carefully check elevations and alignments at each stage of erection and correct as required to avoid a possible accumulation of errors. If geometric corrective measures are necessary as

determined by the Contractor's engineer, the Contractor shall develop the means and methods to ensure the epoxy joint remains watertight and free from localized stress concentrations and submit the corrective measures to the Contractor's engineer for approval. Use shims made of ASTM A240 Type 304 wire cloth (roving) with a maximum of 1/8-inch thickness.

2. Span-by-Span and Wet Joint Erection: Position each span segment according to the final longitudinal alignment, grade, camber, and cross-slope. Keep the horizontal and vertical alignment of the pier segment within 1/16 inch of what is required by the approved erection plans. Correct deviations that are more than this allowed tolerance using a method approved by the Contractor's engineer.
3. Balanced Cantilever and Progressive Cantilever Erection: Check the alignment and elevations of the cantilever(s) using two independent surveys within 1 hour of sunrise on each day that segments are to be erected. Check the measurements made by each survey and ensure they agree to within 1/4 inch. When measurements do not agree, discontinue erection of segments until discrepancies in measurements are resolved to the Contractor's engineer's satisfaction. Accurate positioning of the pier segments is very important, because it will establish the line and grade for cantilevers in each direction. Position each pier segment according to the final longitudinal alignment, grade, and cross-slope, and ensure no further erection continues until and unless these segments are properly located on the piers by the means provided. Keep the pier segment's horizontal and vertical alignments within 1/16 inch of the alignment values required to control points, as established by the approved erection plans. Check at each key stage of erection, in accordance with approved erection procedures, the ends of cantilevers for required elevations and alignment. Correct deviations from the required alignment by a method approved by the Contractor's engineer.

C. Erection Tolerances:

1. Ensure that the maximum differential between outside faces of adjacent segments in the erected position does not exceed 3/16 inch.
2. Ensure that transversely, the angular deviation from the theoretical slope difference between two successive segment joints does not exceed 0.001 radian (rad).
3. Ensure that longitudinally, the angular deviation from the theoretical slope change between two successive segments does not exceed 0.003 rad.
4. Dimensions from segment to segment will compensate for deviations within a single segment, so the overall dimensions of the completed structure meets the dimensions shown on the Construction Drawings such that the accumulated maximum error does not exceed 1/1000 of the span length for either vertical profile and horizontal alignment.
5. Carefully check elevations and alignments at each stage of erection and correct as required to avoid a possible accumulation of errors.

D. Other Miscellaneous Erection Requirements:

1. Span-by-Span and Wet Joint Erection:
   a. Closure Joints: Use concrete meeting the same specifications and criteria as the concrete in the segments. Ensure that concrete reaches the minimum required strength as shown on the Construction Drawings or in these Specifications prior to stressing the continuity post-tensioning. Ensure that the closure joint forms provide tolerances as specified under Article entitled "Fabrication" under "Age at Erection" herein.

b. Wet Joints: Where forming joints between segments using cast-in-place concrete, the herein above conditions for closure joints also apply to wet joints. In addition, the cast-in-place wet joints cannot be less than 3 inches wide or greater than 9 inches wide, unless otherwise approved by the Contractor's engineer.

c. Formwork: Adequately support formwork at all wet joints and closure joints to take all loads applied, and do not remove them until the concrete in the joints has reached its required strength and the longitudinal tendons have been tensioned.

2. Balanced Cantilever and Progressive Cantilever Erection:

a. Deformations: For computing deformations due to time-dependent stress variations, erection time assumptions are shown on the Construction Drawings. Time dependent deformations due to creep and shrinkage and the concrete modulus of elasticity have been computed using CEB-FIP Model Code 1990. Obtain the Contractor's engineer's approval for the method of calculating these parameters.

b. Temperature Restrictions: Meet the requirements of Article entitled "Epoxy Jointing of Precast Segments" under "Construction Requirements" under "Substrate Temperatures and Epoxy Formulation" herein, for substrate temperatures, epoxy formulation, and thermal controls where precast segments are jointed with epoxy. Measure the substrate temperature at the mid-depth of the top slab for box girder sections or 4 inches from the top surface for slabs and other sections.

c. Permissible Loads on Cantilever: During balanced cantilever erection, unbalance the cantilever by only one segment at a time. In addition to the unbalanced load due to one segment, the cantilevers are designed for loads applied by the erection equipment, as listed on the Construction Drawings. Use alternate erection methods that comply with the assumptions on the Construction Drawings or are otherwise approved by the Contractor's engineer.

d. Span Closure Joints: Use concrete for closure joints that comply with the same specifications and criteria as the concrete in the segments. Ensure that concrete reaches the minimum required strength shown on the Construction Drawings or in these Specifications prior to stressing the transverse or continuity post-tensioning. Ensure that the closure joint forms provide tolerances as specified for precast segments.

e. Falsework and Formwork: Support falsework and formwork at closure pours by the cantilever ends or terminating segments of each series of segments to be joined. Secure cantilever together vertically, longitudinally, and transversely so the applied loads will yield equal deflections to both cantilevers. Do not remove securing devices until the closure pour concrete has reached its required strength and longitudinal continuity tendons are tensioned. Submit calculations and details to verify that the devices and methods have adequate rigidity and do not impose excessive loads and stresses on the structure.

3. Precast Box Pier Construction – Erection Tolerances:

a. Ensure that the maximum differential between outside faces of adjacent segments in the erected position does not exceed 3/16 inch.

b. Ensure that the rotational angular deviation (measured about a vertical line) between two successive segment joints does not exceed 0.001 rad.

c. Ensure that the maximum angular deviation of a segment from a vertical line does not exceed 0.003 rad and that the maximum overall deviation from the vertical, measured in any direction, does not exceed 0.01 inch per foot of height.

d. Ensure the base precast segment is within 1/2 inch of the plan location.

3.2 EPOXY JOINTING OF PRECAST SEGMENTS

A. Description: Furnish, mix, and apply a two-component epoxy bonding system to the match-cast faces of joints between precast concrete superstructure and substructure segments, in accordance with the Contract Documents. In its workable state or open time, the epoxy bonding agent shall function as a lubricant for joining the segments. In its hardened state, the epoxy bonding agent shall provide a watertight seal between the precast concrete segments. The hardened epoxy bonding agent shall provide intimate contact for stress transfer by completely filling all interstitial space between the match-cast segment faces. This Section applies to precast segmental structures with multiple shear joints in webs and joints with suitable shear keys in precast substructure segments.

B. Qualifications of Contractor’s Personnel: For mixing, handling, and applying the epoxy bonding agent, a person who has knowledge and experience or has been trained by a technical representative of the manufacturer in the use of this material shall provide direct supervision. Arrange for a technical representative of the manufacturer to be at the site as an advisor at the beginning of this work. Ensure that all personnel who will be working with the epoxy bonding agent are thoroughly familiar with the safety precautions necessary for use of this material.

C. Construction Requirements:

1. General: Apply an epoxy bonding agent that meets this Section’s requirements to mating surfaces of all match-cast precast concrete segments. Prior to the manufacture of epoxy for this work, a site meeting will be held with representatives from the Contracting Officer, the Contractor, the Contractor’s engineer, and the epoxy manufacturer to discuss selection of the proper formulations, storage and handling, and mixing and application of the epoxy. Necessary cleaning materials shall be immediately available at the location of the segment joining, in the event that segments shall be separated and cleaned or epoxy shall be reapplied. In the Erection Manual, include details of erection and post-tensioning operations that ensure that the elapsed time between mixing components of the first batch of epoxy bonding agent applied to the joining surfaces of precast concrete segments and application of a compressive contact pressure across the joint does not exceed 70 percent of the open time for the particular formulation of epoxy bonding agent used. Also include details on how the minimum, closing, contact pressure of approximately 40 psi will be applied uniformly to each joint to which epoxy is applied during the epoxy curing period. Contact pressure may be attained through combinations of weight and temporary and permanent post-tensioning.
2. Cleanliness of Surfaces to be Joined: Ensure that application surfaces are free from oil, form-release agent, laitance, or other deleterious materials that would prevent the epoxy bonding agent from bonding to the concrete surface. Remove laitance by light sandblasting and wire brushing. Do not destroy the surface shape and profile of the mating surfaces. Ensure that surfaces have no free moisture on them at the time the epoxy bonding agent is applied. Free moisture will be considered present if a dry rag, after being wiped over the surface, becomes damp.
3. Substrate Temperatures and Epoxy Formulation: Apply epoxy bonding agent only when the substrate temperature of both surfaces to be joined is between 40 and 115 degrees Fahrenheit. The formulation of the epoxy bonding agent shall have an application temperature range that conforms to the substrate temperature of the surfaces being joined. If the mating surfaces have different substrate temperatures, use the formulation for the higher temperature in hot weather periods. Thermal control precautions may be taken in

accordance with Article entitled "Epoxy Jointing of Precast Segments" under "Construction Requirements" under "Thermal Controls" herein.

4. Mixing of Epoxy Bonding Agent: Mix the two components of the epoxy bonding agent in strict accordance with the manufacturer's instructions, using only full and undamaged containers. Only open the containers immediately before being combined, and do not use containers that have an expired shelf life. Thoroughly stir each container of component before combining components. Combine the two components and thoroughly mix until a uniform color is achieved. Mix with a properly sized mechanical mixer operating at no more than 600 revolutions per minute (rpm) and in accordance with the epoxy manufacturer's recommendations. Do not mix until the segments to be joined are within approximately 18 inches of their final position. Schedule mixing of the epoxy bonding agent so that the material in a batch is applied to the face of a joint within a maximum of 20 minutes after combining the components. The Contracting Officer, at its discretion, may require a dry run to check the fit of two surfaces before applying the epoxy.
5. Application and Amount of Epoxy: Begin application immediately after a batch has been mixed. Uniformly apply the epoxy bonding agent in accordance with the manufacturer's recommendations, by spatula or gloved hand and at a nominal thickness of 1/16 inch. Apply epoxy to all areas of both faces to be joined. Do not exclude epoxy from around holes formed by ducts. Apply additional epoxy thickness, equal to the shim thickness, to segment faces when shims are placed in a joint. The amount of epoxy may be adjusted, provided that a sufficient amount is applied to completely fill all interstitial space in the joint and to extrude a small bead from the joint after application of the compressive contact pressure. If a bead of epoxy is not extruded all around the joint, determine the reason why before proceeding. Do not use an epoxy bonding agent from a batch for which the time since combining the components has exceeded 20 minutes.
6. Mating of Segments: Immediately after each mating surface is covered with epoxy bonding agent, bring the segments together and apply the specified compressive contact pressure in accordance with the approved erection procedures. Contact pressure may be increased after the epoxy has taken an initial set. Do not reduce contact pressure until the epoxy in the joint has properly hardened and cured. If contact pressure is reduced, do not subject the joint to tensile stress. A discernable bead line of extruded epoxy bonding agent shall be apparent along the exposed edges of the joint. Fill all areas of the joint that do not show a bead of epoxy by dispensing additional epoxy that meets the requirements of these Specifications into the joint using a pneumatic gun with epoxy cartridges. Inject epoxy to a minimum depth of 1 inch. Catch and retain epoxy that is squeezed out of the joint in areas over waterways, roadways, and buildings. Clean all extruded epoxy bonding agent from external visible surfaces in a way that does not damage or stain the concrete surface. Do not smear surplus extruded epoxy bonding agent over large areas (areas more than 1 inch from each side of the joint), visible surfaces, or surfaces to which a cover coat or texturing is to be later applied. Immediately after the segments are joined, swab all embedded (internal) post-tensioning ducts or conduits passing through the joints to smooth out extruded epoxy bonding agent. If the time between combining the components of the epoxy bonding agent and applying the compressive contact pressure exceeds 70 percent of the minimum open time, immediately separate the segments and clean in accordance with Article entitled "Epoxy Jointing of Precast Segments" under "Construction Requirements" under "Failure to Comply with Time Limits or Incomplete Jointing" herein.
7. Thermal Controls: Cooling in Hot Weather: If the substrate temperature exceeds 115 degrees Fahrenheit, do not proceed with epoxy jointing. The Contractor may take precautions to keep the mating substrate surfaces cool by shading and wetting with clean water, except that the herein above requirements for no moisture at the time of application shall be strictly adhered to.

8. Failure to Comply with Time Limits or Incomplete Jointing: If the time limit between mixing the epoxy bonding agent and applying contact pressure is exceeded or if the joint is incompletely filled and sealed, separate the segments and remove all epoxy from the faces using spatulas and approved solvent. Do not re-apply epoxy until the faces have been properly cleaned and solvents dispersed, for a period of 24 hours.

D. Removal of Support to Segments:

1. Span-by-Span Erection: Ensure that precast concrete segments remain fully supported by the erection truss or system until at least 20 hours after mixing of the last batch of epoxy bonding agent applied to any joint in the span.
2. Cantilever Erection: Independent support to a newly erected cantilever segment may be removed when the epoxy bonding agent in the third previous mating joint has set. It is not necessary for the epoxy bonding agent in the new joint or the immediately previous joint to be set prior to removing the independent support of the new segment, provided that temporary and permanent post-tensioning has been installed to carry the load of the new and previous segment along with any applied construction loading, in accordance with the requirements of the erection system.

E. Record of Jointing: Record and submit on a weekly basis the following information:

1. General:
   a. Date and time of jointing
   b. Segment numbers or spans jointed
   c. Weather conditions

2. For each joint (identified by location or segment numbers):
   a. Manufacturer's lot number of epoxy bonding agent components
   b. Temperature of the concrete on the joint surface at the middle of each segment when application of the epoxy bonding agent began
   c. Time of mixing first batch of epoxy bonding agent applied to the joint and completion of application
   d. Time of applying the required compressive contact pressure

3. Details of repairs performed, including the reason for repair, joint location, volume of epoxy used, and method of application.

3.3 PACKED MORTAR JOINTS FOR JOINTS, BEARINGS, OR SETTING PIER SHAFT SEGMENTS

A. Where designated on the Construction Drawings, place packed mortar after the precast element or bearing has been set at the proper final elevation. Pressure grouting the joint may be allowed with the Contractor's engineer's approval of the materials and method to be used. Additionally, where precast piers are shown connected to the footings by packed mortar, temporarily supporting the base segment and casting the footing around the segment will be allowed. Minimum penetration of the base segment into the footing shall be 2 inches. No additional payment for this operation or for additional footing concrete will be made. Mortar for packing shall consist of one part cement and one part fine aggregate, by volume, mixed with a non-shrink admixture as recommended by the manufacturer. Mix the dry elements thoroughly to a uniform mixture. Add water to produce a mealy, slightly adhesive mixture. Pack the mortar until a water sheen is produced on the surface of the mortar. Build a form around the joint leaving one side open. Secure the form to withstand required packing forces. Insert a small amount of mortar into

the open joint to form a 2-inch-thick bead on the opposite side of the form. Pack this bead by striking a special tool made of 1/2-inch by 2-inch steel with a length approximately 10 inches longer than the largest dimension of the joint being packed with a 2-pound hammer. Continue compaction until water begins to bleed out of the mortar. When bleeding has occurred, insert another bead of mortar and pack as described herein above. Continue this process until the joint is filled to the limits shown in the Construction Drawings.

3.4 WATERTIGHT DECKS

A. Check all segment joints, closure joints, and deck hole repairs to assure every location is watertight, upon completion of all milling and grinding activities on the riding surface. Repair all locations showing evidence of leaks by cutting a 3/8-inch-wide x 5/8-inch-deep groove along the leak interface. Clean and completely fill the groove with epoxy meeting the requirements of Articles entitled “Epoxy Bonding Systems” and “Epoxy Jointing of Precast Segments” herein. Dispense the epoxy into the groove using a pneumatic gun and epoxy cartridges. Clean all excess epoxy bonding agent from external visible surfaces in a way that does not damage or stain the concrete surface. Do not smear epoxy over areas located more than 1 inch from each side of the groove.

3.5 STRESSING OF TENDONS

A. Prestressing shall be performed by methods and related equipment in adherence with Section 03 05 18, Prestressed Concrete.

3.6 GROUTING OF DUCTS

A. Grouting equipment and procedures shall meet the requirements of Section 03 05 18, Prestressed Concrete, and the following:

B. Transverse and vertical tendons shall be grouted within 10 days of stressing. Longitudinal tendons, tendons in pier diaphragms, and expansion joints shall be grouted within 14 days of stressing. If tendons are not grouted in 14 days after stressing, they shall be protected from corrosion. These tendons shall be grouted within 60 days.

3.7 FORMING AND REPAIR OF HOLES AND BLOCKOUTS

A. Forming and repair of holes and blockouts in accordance with Section 03 05 18, Prestressed Concrete.

3.8 FIELD QUALITY CONTROL

A. Refer to Article entitled “Fabrication and Erection Quality Control” for testing required for erection phase.

3.9 PROTECTION OF POST-TENSIONING ANCHORAGES

A. Protection of post-tensioning anchorages in accordance with Section 03 05 18, Prestressed Concrete

END OF SECTION

SECTION 03 62 00

NON-SHRINK GROUTING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Cementitious Grout.

B. Epoxy Grout.

C. Epoxy Adhesive.

1.2 RELATED SECTIONS

A. Grout for prestressed concrete is specified in Section 03 05 18, Prestressed Concrete.

1.3 DEFINITION

A. For the purpose of these Specifications, "non-shrink grout" shall be defined as a high-strength mortar or grout, which does not shrink in the plastic state, is dimensionally stable in the hardened state, and bonds permanently. Non-shrink grout is used for applications such as bonding to a clean metal baseplate and concrete substrate.

1.4 REFERENCE STANDARDS

A. American Concrete Institute (ACI):

1. ACI 503.2 — Specification for Bonding Plastic Concrete to Hardened Concrete with a Multi-Component Epoxy Adhesive

B. ASTM International (ASTM):

1. ASTM C109 — Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or 50-mm Cube Specimens)
2. ASTM C157 — Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete
3. ASTM C579 — Standard Test Methods for Compressive Strength of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings and Polymer Concretes
4. ASTM C827 — Standard Test Method for Change in Height at Early Ages of Cylindrical Specimens of Cementitious Mixtures
5. ASTM C881 — Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
6. ASTM C1090 — Standard Test Method for Measuring Changes in Height of Cylindrical Specimens of Hydraulic-Cement Grout
7. ASTM C1107 — Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Non-shrink)

C. U. S. Army Corps of Engineers, Concrete Research Division (CRD):

1. CRD-C620 Standard Method of Sampling Fresh Grout
2. CRD-C621 Specification for Non-shrink Grout

1.5 SUBMITTALS

A. Product Data: Submit manufacturer's product data and installation instructions.

B. Certification: Submit certificates of compliance or laboratory test reports which indicate the following:

1. Materials used in the grout are free from metallic components and corrosion-producing elements.
2. Materials meet specified shrinkage and compressive strength requirements.

1.6 ENVIRONMENTAL REQUIREMENTS

A. Handle grout the same as concrete with regard to temperature and curing, as specified in Section 03 30 00, Cast-In-Place Concrete, Section 03 05 18, Portland Cement Concrete, and Section 03 35 00, Concrete Finishing.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Cementitious Grout: Provide non-shrink, non-metallic, non-corrosive cement-based grout conforming to the following requirements:

1. Applicable Standards: ASTM C1107 and CRD-C621.
2. Grout shall be manufactured specifically for use in supporting heavy loads (loads in excess of 300 pounds per square foot concentrated load or 100 pounds per square foot uniform load). Grout: ASTM C1107, Grade A, B, or C, as appropriate for the condition or circumstance.
3. Shrinkage at 28 days: No shrinkage before hardening (0.00 shrinkage when tested in accordance with ASTM C827); no shrinkage after hardening (0.00 shrinkage when tested in accordance with CRD-C621).
4. Compressive strength, minimum:
   a. At 1 day: 1000 psi
   b. At 3 days: 2500 psi
   c. At 7 days: 3500 psi
   d. At 28 days: 5000 psi
5. Initial setting time, after addition of water: approximately one hour at 70 degrees F.
6. Provide nonsag trowelability or flowability as necessary for the particular application.

B. Water: Clean and potable, free of impurities detrimental to grout.

C. Epoxy Grout: Provide non-shrink, non-metallic, non-corrosive epoxy grout conforming to the following requirements:

1. Grout shall be manufactured specifically for use in supporting heavy loads.

2. Shrinkage at 28 days: None (0.00 shrinkage when tested in accordance with ASTM C827 modified procedure) with a minimum effective bearing area (EBA) of 95 percent coverage of the tested base plate.
3. Compressive strength, minimum: 10,000 psi at 7 days, when tested in accordance with ASTM C579.
4. Initial setting time: Approximately 1 hour at 70 degrees F.
5. Provide flowable consistency as necessary for the particular application.
6. Epoxy grouts, which are volatile and which give off noxious fumes, are not acceptable.

2.2 Epoxy Adhesive: ASTM C881, Type V, epoxy-based bonding agent.SOURCE QUALITY CONTROL

A. Inspections and Tests: Perform visual inspections and shrinkage tests using an appropriate independent testing laboratory, and strength tests as necessary to verify performance requirements of grout. Sampling and testing of grout shall conform to applicable ASTM or CRD-C620 requirements.

B. Visual Inspections: Perform visual inspection of the grout mixing and placement to determine and verify that grout consistency, slump, and stiffness are appropriate and proper for the location and type of installation.

C. Shrinkage Tests:

1. Cementitious Grout: Grout shall meet the following performance requirements:
   a. Expansion: 0.4 percent maximum at 3, 14, and 28 days. Grout shall exhibit no displacement when tested in accordance with ASTM C157.
   b. Shrinkage: None (0.00 shrinkage at 28 days when tested in accordance with ASTM C827 and ASTM C1090). There shall be no vertical volume shrinkage of grout in the plastic or hardened stage at any time.

2. Epoxy Grout: Grout shall meet the following performance requirements:
   a. Expansion: Grout shall exhibit no displacement when tested in accordance with ASTM C827 and ASTM C157, modified procedures.
   b. Shrinkage: None (0.00 shrinkage when tested in accordance with ASTM C827, modified procedure; specific gravity of indicator ball will be changed to approximately 1.0).
   c. Effective Bearing Area: 95 percent minimum coverage of the tested base plate.

D. Strength Tests: Compressive strength of grout shall meet the following requirements:

1. Cementitious Grout: 5,000 psi minimum at 28 days when tested in accordance with ASTM C109.
2. Epoxy Grout: 10,000 psi minimum at 7 days when tested in accordance with ASTM C579.

PART 3 - EXECUTION

3.1 SURFACE PREPARATION

A. Concrete surfaces to receive grout shall be prepared by chipping, sandblasting, water blasting, or other accepted methods to remove defective concrete, laitance, dirt, oil, grease, and other foreign

matter to achieve sound, clean concrete surfaces. Lightly roughen concrete for bond, but not enough to interfere with proper placement of grout.

B. Cover concrete areas with protective waterproof covering until ready to place grout.

C. Remove foreign matter from steel surfaces to be in contact with grout. Clean contact steel surfaces as necessary by wire brushing and wiping dust clean.

D. Align and level components to be grouted, and maintain in final position until grout placement is complete and accepted.

E. Install forms for grout around the column base plates and other spaces to be grouted. The tops of such forms shall be one inch above the surfaces to be grouted.

F. Remove protective waterproof covering and clean contaminated surfaces immediately before grouting.

G. Provide air-relief holes in large baseplates and in baseplates where underneath obstructions may cause air entrapment.

H. Saturate concrete surfaces with clean water, and remove excess water immediately before grouting.

I. Where necessary or appropriate for better bond, epoxy adhesive may be applied to clean, dry substrate surfaces in accordance with applicable requirements of ACI 503.2.

3.2 MIXING

A. Mix grout ingredients for both cementitious grout and epoxy grout in accordance with the respective manufacturer's mixing instructions and recommendations. Mix grout materials in proper mechanical mixers.

B. Mix grout as close to work area as possible.

3.3 PLACING GROUT

A. Place grout in accordance with the respective manufacturer's installation instructions and recommendations. Pour grout from one side only until grout rises at least one inch above the plate on opposite side of said plate. Strapping and plunging or other recommended method may be used to force grout to flow under the entire area.

B. Neatly trowel edges of grout base, tapered at an angle of 60 degrees when measured from the horizontal, or as indicated. Provide dry-pack cementitious grout where additional grout is required for shoulders.

C. Do not remove leveling shims for at least 48 hours after grout has been placed.

D. After shims have been removed, if used, fill voids with grout, packing the material with a suitable tool.

E. Do not use grout which has begun to set or if more than one hour has elapsed after initial mixing.

3.4 CURING

A. Cementitious grout shall be cured the same as specified for concrete in Section 03 35 00, Concrete Finishing.

B. Epoxy grout shall be cured as recommended by the grout manufacturer.

END OF SECTION

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SECTION 03 70 00

MASS CONCRETE

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Cement.

B. Coarse aggregate.

C. Fine aggregate.

D. Concrete admixtures.

E. Water and ice.

F. Concrete mix design.

G. Concrete mixing.

1.2 RELATED SECTIONS

A. Portland cement concrete is specified in Contract Specifications Section 03 05 15, Portland Cement Concrete.

B. Cast-in-place concrete is specified in Contract Specifications Section 03 30 00, Cast-In-Place Concrete.

1.3 REFERENCE STANDARDS

A. American Concrete Institute (ACI)

1. ACI 207.1R Mass Concrete
2. ACI 207.2R Effect of Restraint, Volume change, and Reinforcement on Cracking of Mass Concrete
3. ACI 207.4R Cooling and Insulating Systems for Mass Concrete

B. ASTM International (ASTM):

1. ASTM C494 Standard Specification for Chemical Admixtures for Concrete
2. ASTM C989 Standard Specification for Slag Cement for Use in Concrete and Mortars
3. ASTM C1240 Standard Specification for Silica Fume Used in Cementitious Mixtures

1.4 SUBMITTALS

A. Submittals specified in Section 03 05 15, Portland Cement Concrete, plus the additional submittals listed herein.

B. Gradation of coarse and fine aggregates and a combined gradation of coarse and fine aggregates.

C. Temperature Control Plan that considers the expected ambient temperature at the time of concrete placement and maximum temperatures within the concrete. The plan shall include the following:

1. Temperature monitoring system including manufacturer's information on sensing devices and data recorder, and plan showing the location of sensing devices.
2. Calculations on the expected maximum temperature, temperature rise and temperature differential for each large concrete placement. Calculations must consider the heat gains (or losses) of the concrete and ingredients during batch plant storage, during concrete mixing, and during the transportation and placing of the concrete.
3. Pre-cooling procedures including temperature of concrete at placement, cooling batch water, use of ice with batch water, cooling fine and course aggregate, and measures to prevent heating aggregate by direct sunlight.
4. Special requirements to reduce the affects of ambient temperature on the concrete at the time of placement.
5. Post-cooling procedures that may include either water curing or a cooling pipe system.
6. An outline of corrective actions to maintain the allowable temperature differential.

D. Repair Methods or Corrective Actions: Submit proposed methods of repairs or corrective actions if the mass concrete member is not accepted.

E. Layout of cooling pipe system if used, showing pipe sizes and material type, connections, location, spacing, method of support, and system for monitoring temperature of the water in the cooling pipes.

F. Submit Concrete Placement Plan for all large concrete placements. Represent as accurately as possible the expected conditions at the item of the concrete placement. The Plan shall include the following:

1. Volume of concrete to be placed and expected duration.
2. Schedule identifying all critical activities and list start time, duration, and expected finish.
3. Number of concrete trucks required. Travel route from mixing plant to site. Identify all traffic mitigation measures to be taken to avoid potential disruption to the scheduled delivery of the concrete.
4. Production rate of mixing plant.
5. Method of concrete placement including anticipated interruptions and time intervals between lifts.
6. Expected ambient temperature at time of placement and ambient temperature variation during cooling period.
7. Curing and cooling procedures to be implemented based on expected ambient temperatures at time of concrete placement and maximum temperatures in the concrete, including procedures for Hot or Cold Weather Concrete conditions.

G. Daily Reports: Submit daily reports of temperature monitoring of concrete.

1.5 QUALITY ASSURANCE

A. Comply with requirements of Section 03 05 15, Portland Cement Concrete.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Cement: Furnish from one source. Portland Cement Type II:

1. Tricalcium Aluminate Content of Cement: Maximum 8 percent.
2. Sum of Tricalcium Aluminate and Tricalcium Silicate: Maximum 48 percent.

B. Supplementary Cementitious Materials (SCM):

1. Fly Ash and other Pozzolans: Conform to the requirements of Section 03 05 15, Portland Cement Concrete.
2. Ground granulated blast furnace slag (GGBFS). Conform to ASTM C989.
3. Silica Fume: Conform to ASTM C1240.

C. Coarse Aggregate:

1. Size: Maximum 1.5 inches.
2. Grading: Conform to the requirements of Table 2.5.8, ACI 207.1R.
3. Conform to the requirements of Section 03 05 15, Portland Cement Concrete.

D. Fine Aggregate:

1. Conform to the requirements of Section 03 05 15, Portland Cement Concrete.

E. Concrete Admixtures:

1. Water Reducing Admixture: Conform to the requirements of Section 03 05 15, Portland Cement Concrete.
2. Set Retarding Admixture:
   a. Use of set retarding admixtures is optional.
   b. Conform to the requirements of ASTM C494, Type B.
   c. Use dosage as recommended by the manufacturer's written requirements after approval by the Contractor’s engineer.

F. Water and Ice:

1. Use mixing water that conforms to the requirements of Section 03 05 15, Portland Cement Concrete.
2. Use mixing water that conforms to the requirements of Section 03 05 15, Portland Cement Concrete, to make ice used in lieu of or in addition to mixing water.

2.2 CONCRETE MIX DESIGN

A. Mix design used for mass concrete shall conform to the provisions in Section 03 05 15, Portland Cement Concrete, with the exceptions specified in this Article:

B. Select concrete ingredients (including aggregates, gradation, and cement types) that minimize the heat of hydration.

C. Cementitious Material:

1. Mass concrete shall contain a minimum of 505 pounds of cementitious material per cubic yard of concrete. Mass concrete for drilled shafts shall not contain more than 720 pounds of cementitious material per cubic yard of concrete.
2. To better control the heat of hydration of the mass concrete, the concrete mix design shall contain a pozzolanic material such as fly ash, silica fume, or ground granulated blast furnace slag (GGBFS).
    a. When supplementary cementitious (SCM) material is GGBFS, the amount of SCM shall be 50 to 70 percent by weight of the total cementitious material used in the mix.
    b. When the SCM is not GGBFS, the SCM content shall be from 25 to 35 percent of the total cementitious material by weight used in the mix.

D. Design: Select and proportion ingredients using laboratory trial mixes. Sample, cure, and test laboratory trial mix through an accredited testing laboratory. Submit laboratory test results on the trial mix to the Contractor's engineer prior to concrete placement.

1. Concrete Compressive Strength, F'_c
    a. 4,000 psi at 42 Days.
    b. Design lab-cured mix cylinders.
    c. Use additional cement or cementitious material above minimum specified if required to meet average compressive strength, F'_c

E. Proportions:

1. Water-Cement Ratio: Maximum of 0.50.
2. Entrained Air Content: Maximum of 4.0 percent.
3. Slump: 3 to 5 inches.

2.3 CONCRETE MIXING

A. Comply with the requirements of Section 03 05 15, Portland Cement Concrete.

PART 3 - EXECUTION

3.1 TRANSPORTING, CONVEYING AND PLACING, AND CONSOLIDATING

A. Comply with the requirements of Section 03 30 00, Cast-In-Place Concrete, except as modified herein.

3.2 TEMPERATURE CONTROL

A. General:

1. At the time of concrete placement, have temperature control measures in place to limit the maximum initial concrete temperature to 50 degrees F. Do not allow the temperature of the concrete to exceed 135 degrees F at any time.
2. Do not allow the difference in temperature between the interior and surface of the concrete to exceed 35 degrees F.

3. Install a temperature monitoring system to measure temperatures within the interior and the surface of the concrete. Provide two sets of three sensors for every 500 cubic yards of concrete being placed. The devices must operate in the range of 32 to 212 degrees F with an accuracy of plus or minus 2 degrees F. Connect sensing devices with armor sheath wire. Obtain and document the Contractor’s engineer’s approval of the location of the devices. The temperature monitoring system shall provide information for the control or concrete cooling rates and evaluate the need for additional cooling or insulation.
4. Allow the interior of the concrete to cool down and stabilize a minimum of 14 Days after placement.
5. Do not place concrete until the Contractor’s engineer has provided written approval of the Temperature Control Plan.

B. Temperature Sensing Equipment: Use thermistor-type temperature-sensing devices or an equal device approved by the Contractor’s engineer capable of indicating temperatures over a range of 50 to 200 degrees Fahrenheit, with an accuracy and precision of plus or minus 1 degree Fahrenheit. Connect the sensors to a device that continuously records and displays temperatures and produces a record that can be detached and filed.

1. Temperatures shall be recorded automatically by a strip-chart recorder approved by the Contractor’s engineer.

C. Pre-Cooling of the Concrete Mix: When required, implement measures to pre-cool concrete mix to avoid placement above required maximum temperatures. Measures include:

1. Cool batch water; ice may be substituted for a portion of the batch water.
2. Store all aggregates to prevent heat absorption and heating by direct sunlight.
3. Store cement to prevent heat absorption and heating by direct sunlight.
4. Spray coarse aggregate stockpiles with water for an evaporative cooling effect.
5. Place concrete late in the evening, over night, or in the early morning hours.
6. Alternative methods may be used if approved by the Contractor’s engineer.

D. Cooling During Concrete Placement: Use fog sprayers to reduce the ambient air temperature during placement.

E. Post-Cooling of the Concrete Mix:

1. Water cure the concrete as soon as possible after placement in accordance with the requirements of Section 03 30 00, Cast-In-Place Concrete.
2. Continuously monitor the temperature of the interior and surface of the concrete during the cooling period. In the event the data shows higher than expected temperatures in the concrete, take appropriate measures and remedy the situation and adjust procedures for subsequent concrete placements accordingly.
3. The cooling period is defined as the time required for the interior of the concrete placement to stabilize, a minimum of 14 Days after placement.
4. Embedded thin walled piping and circulating water may be used to control heat gain in the previously cast concrete. If used, clearly indicate this option in the Temperature Control Plan. Do not install embedded piping within the top 20 inches of the slab or wall. Operate the cooling system for the duration of the cooling period.

END OF SECTION

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SECTION 05 05 22

METAL WELDING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Welding Rod/Electrodes.

B. Stud Shear Connectors.

C. Shop Welding.

D. Inspections and Tests by the Contractor.

1.2 RELATED SECTIONS

A. Welding of reinforcing steel for concrete is specified in Section 03 20 00, Concrete Reinforcing.

B. Welding of H-piles and pipe shells for piles is specified in Section 31 62 00, Driven Piles.

C. Welding and brazing of piping for plumbing and mechanical systems are specified under the applicable Sections.

1.3 REFERENCE STANDARDS

A. American Institute of Steel Construction (AISC):

1. AISC 341 Seismic Provision for Structural Steel Buildings Including Supplement No. 1

B. American Society for Nondestructive Testing (ASNT):

1. SNT-TC-1A Recommended Practice: Personnel Qualification and Certification in Nondestructive Testing

C. ASTM International (ASTM):

1. ASTM E94 Standard Guide for Radiographic Examination
2. ASTM E164 Standard Practice for Contact Ultrasonic Testing of Weldments
3. ASTM E165 Standard Practice for Liquid Penetrant Examination for General Industry
4. ASTM E709 Standard Guide for Magnetic Particle Testing
5. ASTM E1032 Standard Test Method for Radiographic Examination of Weldments

D. American Welding Society (AWS):

1. AWS A2.4 Standard Symbols for Welding, Brazing and Nondestructive Examination
2. AWS A3.0 Standard Welding Terms and Definitions, Including Terms for Adhesive Bonding, Brazing, Soldering, Thermal Cutting and Thermal Spraying
3. AWS A5 Welding Rods, Electrodes, and Filler Metals Series

4. AWS A5.4 Specification for Stainless Steel Electrodes for Shielded Metal Arc Welding
5. AWS A5.9 Specification for Bare Stainless Steel Electrodes and Rods
6. AWS A5.10 Specification for Bare Aluminum and Aluminum-Alloy Welding Electrodes and Rods
7. AWS B1.10 Guide for the Nondestructive Inspection of Welds
8. AWS C5.4 Recommended Practices for Stud Welding
9. AWS D1.1 Structural Welding Code - Steel
10. AWS D1.2 Structural Welding Code - Aluminum
11. AWS D1.3 Structural Welding Code - Sheet Steel
12. AWS D1.4 Structural Welding Code - Reinforcing Steel
13. AWS D1.5 Bridge Welding Code
14. AWS D1.8 Structural Welding Code – Seismic Supplement
15. AWS D9.1 Sheet Metal Welding Code
16. AWS D10.4 Recommended Practices for Welding Austenitic Chromium-Nickel Stainless Steel Piping and Tubing
17. AWS D10.9 Specification for Qualification of Welding Procedures and Welders for Piping and Tubing
18. AWS QC 1 Standard for AWS Certification of Welding Inspectors

1.4 REGULATORY REQUIREMENTS

A. In addition to the foregoing referenced standards, the regulatory requirements that govern the work of this Section include the following codes:

1. California Code of Regulations, Title 24, Part 2, California Building Code (CBC), Chapter 17, “Structural Tests and Special Inspections”.
2. California Code of Regulations, Title 24, Part 2, California Building Code, Chapter 22, “Steel”, and State Chapter 22A, “Steel”.

1.5 SUBMITTALS

A. For shop drawings and other submittals, employ the standard welding symbols of AWS A2.4 and the standard welding terms of AWS A3.0.

B. Welder Qualifications: Submit copies of qualification test records for each welder, welding operator, and tack welder to be employed in the work. Comply with requirements of AWS D1.1. For bridgework, comply with requirements of AWS D1.5. For aluminum welders, comply with AWS D1.2. For pipe and tube, comply with requirements of AWS D10.9.

1. Submit welders' identification marks (I.D.) for each welder along with qualifications.

C. Welding Procedure Specifications (WPS): Prior to commencement of welding, submit the procedure specifications that will be used for welding. The WPS shall contain all data indicated in AWS D1.1 Annex IV, and other information necessary to produce welded joints in compliance with this specification. For procedures other than those prequalified in accordance with AWS D1.1, D1.2, and D1.5, submit a copy of procedure qualification test records in accordance with the qualification requirements of AWS D1.1, AWS D1.2, and AWS D1.5, as applicable.

D. Welding Records and Data:

1. Submit all radiographs upon completion of fabrication.

2. Submit certifications that magnetic particle and dye-penetrant inspections have been satisfactorily completed.
3. Submit records of ultrasonic testing upon completion.
4. If field welding is permitted, submit descriptive data for field welding equipment.

E. Mill Certificates: Submit mill certificates and certified copy of reports for analyses and tests required by referenced ASTM and AWS specifications.

1.6 QUALITY ASSURANCE

A. Qualifications of Welders and Welding Procedures: Welders, welding operators, tack welders, and welding procedures shall be prequalified or qualified in accordance with the following AWS Welding Codes and Standards:

1. Structural Steel: AWS D1.1, Section 4, Qualification. Includes steel for miscellaneous metalwork, steel stairs, and railings.
2. Stud Welding: AWS D1.1, Section 7.6, Stud Application Qualification Requirements.
3. Structural Aluminum: AWS D1.2, Section 5, Qualification of Procedures and Personnel.
4. Sheet Steel (Structural): AWS D1.3, Section 6, Qualification. Prequalification is not applicable to sheet steel.
5. Concrete Reinforcing Steel: AWS D1.4, Section 6, Qualification. Coordinate with requirements specified in Section 03 20 00, Concrete Reinforcing.
6. Steel for Bridges: AWS D1.5, Section 5, Qualification.
7. Sheet Metal:
    a. Welders: AWS D9.1, Section 4, Qualification of Arc Welders and Arc Welding Operators, and Section 9, Qualification of Braze Welders and Braze Welding Operators.
    b. Welding Procedures: AWS D9.1, Section 3, Arc Welding Procedure Qualification, and Section 8, Braze Welding Procedure Qualification.

8. Pipe and Tube: AWS D10.9

B. Qualifications of Welding Inspector: Welds to be inspected by the Contractor shall be inspected and certified by a Contractor-employed AWS Certified Welding Inspector (CWI), certified in accordance with AWS QC 1.

C. Qualification of Personnel Performing Nondestructive Testing: Personnel performing nondestructive testing, who are Contractor-employed, shall be qualified and certified in accordance with SNT-TC-1A. Only persons certified for NDT Level I and working under a NDT Level II person or persons certified for NDT Level II may perform nondestructive testing.

D. Weldability of Steel: For structural steel requiring impact test qualification and for corrosion-resistant structural steel, the weldability of the steel and the procedures for welding it shall be established by qualification in accordance with AWS D1.1, Section 4.

E. Qualification of Stud-Connector Manufacturer: Stud shear connector manufacturer shall be qualified in accordance with AWS D1.1, Annex IX, Manufacturers' Stud Base Qualification Requirements.

F. Stud Welding Standards: For stud welding, comply with applicable requirements of AWS C5.4 for steel and stainless steel, and AWS D1.2, Section 7, for aluminum.

G. Moment-Resisting Frames: Welding of beam-to-column joint connections in moment-resisting frames and all seismically related welded joints shall conform to the AISC 341 and AWS D1.8/D1.8M.

H. Iron Contamination of Stainless Steel: Iron contamination of stainless steel will not be accepted. Welds shall be ground smooth and polished at the factory to blend in with the surrounding finish surfaces using methods which prevent iron contamination.

PART 2 - PRODUCTS

2.1 WELDING ROD/ELECTRODES

A. Electrodes for structural plate, shapes, pipe, tubes, and bars shall conform to AWS A5 Series Standards and shall be coated rods or wire of size and classification number as recommended by their manufacturers for the positions and other conditions of actual use. Matching filler metal requirements shall conform to AWS D1.1 and AWS D1.5, as applicable.

B. Electrodes for sheet steel shall conform to AWS A5 Series Standards and shall be coated rods or wire of size and classification number as recommended by their manufacturers for the positions and other conditions of actual use. Matching filler metal requirements shall conform to AWS D1.3.

C. Welding electrodes and welding rods for stainless steel shall conform to AWS A5.4 and AWS A5.9 as recommended by their manufacturers for the positions and other conditions of actual use. Matching filler metals shall be compatible with the Type 316 or Type 304 stainless steel, as applicable.

D. Electrodes for aluminum shall conform to AWS A5.10 Series Standards and shall be coated rods or wire of size and classification number as recommended by their manufacturers for the positions and other conditions of actual use. Matching filler metal requirements shall conform to AWS D1.2.

2.2 STUD SHEAR CONNECTORS

A. Only products of manufacturers qualified in accordance with AWS D1.1, Annex IX, will be accepted for this work.

2.3 SHOP WELDING

A. Perform shop welding as indicated in accordance with the California Building Code, Section 2209 and State Section 2209A, AWS D1.1, AWS D1.2, AWS D1.3, AWS D1.5, AWS D1.8 and AWS D9.1, as applicable to the work.

B. Welders shall mark adjacent to completed welds their welder I.D., using metal stamp, metal engraving, keel, paint stick, or other appropriate marking material.

C. Welding of stud shear connectors shall conform to AWS D1.1, Section 7, Stud Welding, AWS C5.4, and the stud manufacturer's instructions.

D. Welding of stainless steel pipe and tube shall conform to applicable requirements of AWS D10.4.

2.4 INSPECTIONS AND TESTS BY THE CONTRACTOR

A. Visual Inspection: All welds shall be visually examined in accordance with AWS D1.1, Sections 6 and 7.8, as applicable. Quality of welds and standards of acceptance shall be in accordance with AWS D1.1, Section 6.9.

B. Nondestructive Testing: Nondestructive testing shall conform to AWS B1.10.

C. Radiographic Testing: Radiographic testing of welds shall conform to AWS D1.1, Section 6.12 and ASTM E94, and ASTM E1032, as applicable. Complete joint penetration groove welds shall be tested as follows:

1. 10 percent with thickness equal to or less than 3/4 inch.
2. 50 percent with thickness greater than 3/4 inch and equal to or less than 1-1/2 inches.
3. 100 percent for thickness greater than 1-1/2 inches.

D. Ultrasonic Testing: Ultrasonic testing of welds shall conform to AWS D1.1, Section 6.13, and ASTM E164, as applicable. Complete joint penetration groove welds not accessible for radiographic testing shall, with Contractor's engineer's approval, be subjected to ultrasonic testing. The extent shall be the same as specified for radiographic testing.

E. Magnetic Particle Inspection: Magnetic particle inspection of welds shall conform to ASTM E709. Complete and partial joint penetration groove welds and fillet welds shall be inspected as follows:

1. 20 percent of complete joint penetration groove welds of tee and corner joints.
2. 10 percent of partial joint penetration groove welds and fillet welds.

F. Liquid Penetrant Inspection: Liquid dye penetrant inspection of welds shall conform to ASTM E165. Liquid penetrant inspection shall be used for detecting discontinuities that are open to the surface.

G. Repairs: Unacceptable welds shall be repaired in accordance with AWS D1.1, Section 5.26. Repaired or corrected welds shall be reinspected or retested as specified for the original weld.

2.5 SPECIAL INSPECTIONS

A. As applicable, coordinate CBC, Chapter 17, requirements for Special Inspections.

PART 3 - EXECUTION

3.1 FIELD WELDING

A. Field welding, where indicated or permitted by the 'Contractor's engineer, shall be performed as herein specified for shop welding.

3.2 INSPECTIONS AND TESTS

A. Perform inspections and tests of field welds as herein specified for shop welds.

3.3 CLEANING OF STAINLESS STEEL

A. Welds of stainless steel shall be cleaned and protected from damage and corrosion at the factory, during shipping, and at the jobsite until acceptance of the work.

END OF SECTION

SECTION 05 12 00

STRUCTURAL STEEL FRAMING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Structural Steel for Bridges.

B. Structural Steel for Buildings and Other Structures.

C. Structural Tubing.

D. Pipe.

E. Steel Pins.

F. Anchors and Fasteners.

G. Stud Shear Connectors.

H. Forgings.

I. Castings.

1.2 REFERENCE STANDARDS

A. American Association of State Highway and Transportation Officials (AASHTO):

1. AASHTO S2.1 — Steel Bridge Fabrication Guide Specification
2. AASHTO S10.1 — Steel Bridge Erection Guide Specification

B. American Institute of Steel Construction (AISC):

1. AISC 325 — Steel Construction Manual
2. AISC 303 — Code of Standard Practice for Steel Buildings and Bridges
3. AISC 348 — Specification for Structural Joints Using ASTM A325 or A490 Bolts
4. AISC 360 — Specifications for Structural Steel Buildings
5. AISC 341 — Seismic Provisions for Structural Steel Buildings

C. American Railway Engineering and Maintenance-of-Way Association (AREMA):

1. Manual for Railway Engineering (Fixed Properties), herein referred to as the "AREMA Manual", Chapter 15, "Steel Structures"

D. ASTM International (ASTM):

1. ASTM A6/A6M — Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling

2.	ASTM A27/A27M	Standard Specification for Steel Castings, Carbon, for General Application
3.	ASTM A36/A36M	Standard Specification for Carbon Structural Steel
4.	ASTM A47	Standard Specification for Ferritic Malleable Iron Castings
5.	ASTM A48	Standard Specification for Gray Iron Castings
6.	ASTM A53	Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
7.	ASTM A108	Standard Specification for Steel Bars, Carbon and Alloy, Cold-Finished
8.	ASTM A148/A148M	Standard Specification for Steel Castings, High-Strength, for Structural Purposes
9.	ASTM A153	Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
10.	ASTM A194/A194M	Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
11.	ASTM A242/A242M	Standard Specification for High-Strength Low-Alloy Structural Steel
12.	ASTM A307	Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength
13.	ASTM A325	Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
14.	ASTM A370	Standard Test Methods and Definitions for Mechanical Testing of Steel Products
15.	ASTM A449	Standard Specification for Hex Cap Screws, Bolts and Studs, Steel, Heat Treated, 120/105/90 ksi Minimum Tensile Strength, General Use
16.	ASTM A490	Standard Specification for Structural Bolts, Alloy Steel, Heat-Treated 150 ksi Minimum Tensile Strength
17.	ASTM A500	Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
18.	ASTM A501	Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing
19.	ASTM A514/A514M	Standard Specification for High-Yield-Strength, Quenched and Tempered Alloy Steel Plate, Suitable for Welding
20.	ASTM A563	Standard Specification for Carbon and Alloy Steel Nuts
21.	ASTM A572/A572M	Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel
22.	ASTM A588/A588M	Standard Specification for High-Strength Low-Alloy Structural Steel up to 50 ksi (345 MPa) Minimum Yield Point with Atmospheric Corrosion Resistance
23.	ASTM A618	Standard Specification for Hot-Formed Welded and Seamless High-Strength Low-Alloy Structural Tubing
24.	ASTM A668/A668M	Standard Specification for Steel Forgings, Carbon and Alloy, for General Industrial Use
25.	ASTM A673/	Standard Specification for Sampling Procedure for Impact A673M Testing of Structural Steel
26.	ASTM A709/	Standard Specification for Structural Steel for Bridges
27.	ASTM A913/A913M	Standard Specification for High-Strength Low-Alloy Steel Shapes of Structural Quality, Produced by Quenching and Self-Tempering Process (QST)
28.	ASTM A992/A992M	Standard Specification for Structural Steel Shapes

29. ASTM D4285 — Standard Test Method for Indicating Oil or Water in Compressed Air
30. ASTM F436 — Standard Specification for Hardened Steel Washers
31. ASTM F959 — Standard Specification for Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners

E. American Welding Society (AWS):

1. AWS A2.4 — Standard Symbols for Welding, Brazing and Nondestructive Examination
2. AWS D1.1 — Structural Welding Code – Steel
3. AWS D1.5 — Bridge Welding Code
4. AWS D1.8 — Structural Welding Code – Seismic Supplement

F. Society for Protective Coatings (SSPC):

1. SSPC-SP 1 — Solvent Cleaning
2. SSPC-SP 3 — Power Tool Cleaning
3. SSPC-SP 6 — Commercial Blast Cleaning
4. SSPC-SP 10 — Near-White Blast Cleaning
5. SSPC-SP 11 — Power Tool Cleaning to Bare Metal
6. SSPC-PA 1 — Shop, Field, and Maintenance Painting of Steel
7. SSPC-Paint 20 — Zinc-Rich Primers, Type I - Inorganic and Type II - Organic
8. SSPC-Paint 22 — Epoxy-Polyamide Paints (Primers, Intermediate and Topcoat)

1.3 REGULATORY REQUIREMENTS

A. The regulatory requirements which govern the work of this Section include the following governing code:

1. California Code of Regulations, Title 24, Part 2, California Building Code (CBC), Chapter 17, “Structural Tests and Special Inspections”.
2. California Code of Regulations (CCR), Title 24, Part 2, California Building Code, Chapter 22, “Steel”, and State Chapter 22A, “Steel”.

1.4 SUBMITTALS

A. Shop Drawings:

1. Submit detailed shop drawings of structural steel work prior to fabrication, showing sizes, details of fabrication and construction, methods of assembly, locations of hardware, anchors, and accessories, and erection sequence and details. Include procedures for heavy lifts and rigging. Erection drawings shall be referenced to the Construction Drawings.
2. Shop drawings shall include member identity, welding technique, cuts, copes, gussets, connections, holes, fasteners, camber, fabrication and erection tolerances, type of finish, paint system, weights of members, and critical clearances.
3. Welds, both shop and field, shall be indicated by standard welding symbols of AWS A2.4. Drawings shall show the size, length, and type of each weld.
   a. Indicate individual welders' identification (I.D.) on the project Record Drawings.

4. Investigate stresses caused by the proposed erection procedure. Submit drawings showing details of required temporary supports, staying, and bracing. Include descriptive data and

design calculations, to illustrate the erection, transportation, and handling procedures, including sequence of erecting and transfer of loads if applicable.

5. Furnish setting diagrams, templates, and directions for the erection of structural framing, anchor bolts, bearing plates, and other embedded items.
6. Be responsible for errors of fabrication and for correct fitting of structural members.
7. Detailing Requirements: Requirements for the detailing of structural steel work are specified herein under Part 2 – Products, because of the close relationship of detailing with fabrication requirements.

B. Product Data:

1. Submit manufacturer's product data of load-indicator washers (Compressible-Washer-type direct tension indicators) when proposed for use.
2. Submit manufacturer's product data for shop primer if recommended by the manufacturer of the fireproofing material, including manufacturer of the fireproofing material approval of primer.
3. Submit manufacturer's product data for shop primer for intumescent fireproofing material. Include written recommendation by and approval of the manufacturer of the intumescent fireproofing material.

C. Mill Test Reports:

1. Submit certified mill test reports of structural steel materials, covering chemical analysis and physical properties of each heat of steel from which the material for structural steel will be furnished, in conformance with the ASTM Specifications herein.
2. Steel materials, which are not properly certified as conforming to specified ASTM Specifications, will be rejected.

D. Fabrication Qualifications: Submit documentation of fabricator’s experience in fabrication of structural steel and certification under AISC Quality Certification Program Category III.

E. High-Strength Bolted Connection Reports: Submit inspector’s reports.

F. Welding Records and Data: Refer to Section 05 05 22, Metal Welding, for requirements.

1.5 QUALITY ASSURANCE

A. Fabricator's Shop or Facility: Fabricator's shop or facility will be inspected and approved by the Contractor’s engineer before the start of fabrication work. Fabrication of structural steel shall be performed by an approved fabricator at an approved facility. Fabricator shall have minimum 10 years experience in fabrication of structural steel and shall be certified under AISC Quality Certification Program Category III.

B. Indicated Dimensions: Unless otherwise indicated, dimensions at expansion joints and similar construction were determined for a temperature of 50 degrees F. Make proper adjustments for temperature when the structure is to be fabricated and installed at any other temperature.

C. Tolerances:

1. Variation of camber from indicated dimensions:
   a. Structural rolled beams directly supporting bridge deck: minus zero, plus 1/2 inch for beams 50 feet and shorter, with an additional tolerance of plus 1/8 inch for each 10 feet or fraction thereof in excess of 50 feet.
   b. Welded plate girders: Conform to requirements of AWS D1.1, Article 5.23, Dimensional Tolerance of Welded Structural Members.

2. Measure camber with beam or girder in a no-load position (laid on its side).
3. For beams and trusses that are detailed without specified camber, the member shall be fabricated so that, after erection, any incidental camber due to rolling or shop fabrication is upward.

D. Calibration of Torque Wrenches:

1. The calibrating device for setting calibrated torque wrenches shall be checked for accuracy by the Contractor's qualified personnel not more than 30 days prior to its first use on the work, and at intervals not more than 6 months thereafter.
2. If the Contracting Officer has reason to question the accuracy of the calibrating device, the Contracting Officer may require that it be returned to the manufacturer for certification of its accuracy.
3. Calibrate torque wrenches as specified in AISC 348.

E. Qualifications of Welders and Welding Procedures: Refer to Section 05 05 22, Metal Welding, for requirements.

F. Steel Erector: Steel erector shall have minimum of 10 years of experience in erection of structural steel.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Avoid bending, scraping, and overstressing the steelwork. Block with wood, or otherwise protect, projecting parts, which may be bent or damaged.

B. Mark weight and piece (mark) number, corresponding to shop erection sequence drawing, on all members. Match-mark all shop pre-fitted members.

C. Ship small parts, such as bolts, nuts, washers, pins, fillers, clips, and small connecting plates and anchors, in boxes, crates, or barrels. Pack separately each length and diameter of bolt and each size of nut and washer. Plainly mark an itemized list and description of the contents on the outside of each container.

D. Load, transport, unload, and store structural steel materials in such a manner that the metal is kept clean and free from damage. Store materials above ground on platforms, skids, or other supports, and cover and protect from corrosion.

E. Handle and store beams and girders in such a manner that they will have the required camber after erection.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General: Manufactured steel clips and angles will be accepted where such will meet the requirements of the Construction Drawings and are shown on the shop drawings.

B. Structural Steel for Bridges: ASTM A709/A709M, Grade 36, 50, 50S, 50W, HPS70W, 100 or 100W, as indicated.

1. Identify all materials by heat and lot, if applicable. Correlate with certified mill test reports.
2. Impact Test Qualification: Specific test requirements for Charpy impact testing for grades 36, 50, and 50W shall be as follows:
    a. Sampling and Testing Procedures: ASTM A370 and ASTM A673/A673M, as applicable.
    b. Frequency of Testing: “H” for non-fracture critical; “P” for fracture critical.
    c. Test Temperature: 40 degrees F.
    d. Condition of Material: As-rolled.
    e. Orientation of Test Bars: Longitudinal to the direction of final rolling.
    f. Absorbed Energy Requirements:
        1) Normal-strength steel to 4 inches thick and high-strength steel to 2 inches thick for welded construction and to 4 inches thick for bolted construction: 15 ft-lbf.
        2) High-strength steel, 2 inches to 4 inches thick, for welded construction: 20 ft-lbf.
        3) Subsize Specimens: 12.5 ft-lbf for 10 mm by 7.5 mm specimens, and 10 ft-lbf for 10 mm by 5 mm specimens.

C. Structural Steel for Buildings and Other Structures:

1. M, S, C, and MC Shapes: Standard structural sections, plates, and bars, as indicated, conforming to ASTM A36/A36M. Bars conforming to ASTM A242 or ASTM A514 will be accepted.
2. W-Shapes: Wide-flange sections, as indicated and conforming to ASTM A992 Grade 50, A572 or A913 as applicable to the work.
3. HP Shapes: HP sections, as indicated, conforming to ASTM A572 Grade 50, ASTM A572, or ASTM A913 as applicable to the work.
4. Impact Tests: For rolled shapes of ASTM A6/A6M Groups 4 and 5, shapes built-up by welding plates 2 inches thick or thicker, and supplied weld filler metals subject to tensile stresses, shall be furnished with Charpy V-notch testing in accordance with ASTM A6/A6M Supplementary Requirements S5. Charpy impact testing shall be in accordance with ASTM A370 and ASTM A673/A673M and as specified herein.

D. Structural Tubing (HSS):

1. Cold-Formed Welded and Seamless Carbon Steel: ASTM A500, Grade B or as indicated.
2. Hot-Formed Welded and Seamless Carbon Steel: ASTM A501, minimum yield point of 36,000 psi.
3. Hot-Formed Welded and Seamless High-Strength, Low-Alloy Steel: ASTM A618, Grade as indicated.

E. Pipe: ASTM A53 Grade B (minimum yield point of 35,000 psi).

F. Steel Pins:

1. Greater than 9 inches in diameter: ASTM A668/A668M, Class B, C, or D.
2. Nine inches and less in diameter: ASTM A668/A668M, Class B, C, or D, or ASTM A108, Grades 1016 through 1030.

G. Anchors and Fasteners:

1. Anchors, Bolts, Nuts, and Washers: Bolts and studs, nuts, and washers shall conform to ASTM A307, Grade A, and ASTM A449, ASTM A563, and ASTM F436, as applicable. Bolts and studs, nuts, and washers shall be hot-dip galvanized in accordance with ASTM A153, except bolts, nuts, and washers for structural steel shall be machined items without protective coatings.
2. High-Strength Bolted Connections: Slip-critical type, high-strength bolts. All other threaded fasteners: Furnished with locking hardware.
3. High-Strength Carbon Steel Bolts: ASTM A325, Type 1; except provide Type 3 for corrosion-resistant steel.
4. High-Strength Alloy Steel Bolts: ASTM A490, Type 1; except provide Type 3 for corrosion-resistant steel.
5. Heavy-Duty Hardened Hex Nuts and Washers:
    a. Nuts:
        1) For Type 1 Bolts: ASTM A563, Grade DH or ASTM A194, Grade 2H.
        2) For Type 3 Bolts: ASTM A563, Grade DH3.
    b. Washers: ASTM F436, for use with ASTM A325 or ASTM A490 bolts, as applicable.

6. Load-Indicator Washers: ASTM F959, for use with ASTM A325 or ASTM A490 bolts, as applicable.
7. Lubricant for Bolts: Molybdenum disulfide base.

H. Stud Shear Connectors:

1. Stud connectors shall be produced by cold heading, cold rolling, or cold machining. Finished stud connectors shall be uniform quality and free of injurious laps, fins, seams, cracks, twists, bends, or other defects. Studs shall not have cracks or bursts deeper than one-half the thickness from the periphery of the head to the shaft. Tensile strength of stud connectors shall be determined by tests of bar stock after drawing or of full diameter finished studs. Strength requirements shall conform to the following:

Tensile Strength (min.)	Elongation (min.)	Reduction of Area (min.)
60,000 psi	20 percent in 2 inches	50 percent

2. Stud connectors shall be furnished with arc shields (ferrules) of heat-resistant ceramic or other suitable material for welding.

I. Forgings: ASTM A668/A668M, Class C for carbon steel and Class G for alloy steel.

J. Castings:

1. High-Strength Steel: ASTM A148/A148M, grade as indicated.
2. Mild-to-Medium-Strength Carbon Steel: ASTM A27/A27M, grade as indicated.

3. Malleable Iron: ASTM A47, Grade 35018.
4. Gray Iron: ASTM A48, Class 30B.

K. Welding Electrodes: Refer to Section 05 05 22, Metal Welding, for requirements.

L. Shop Painting Materials: As herein specified under Article entitled “Cleaning and Painting”.

M. Grout: Provide high-strength, non-shrink grout for base plates in accordance with the requirements of Section 03 62 00, Non-Shrink Grouting.

2.2 DETAILING REQUIREMENTS

A. Detailing Standards:

1. Except as specified otherwise herein or as indicated otherwise on the Construction Drawings, detailing and tolerances shall conform to applicable requirements of AISC 360 and AISC 303.
2. Special seismic detailing provisions shall conform to AISC 341 and AWS D1.8.
3. Items to be galvanized shall be detailed as specified in Section 05 50 00, Metal Fabrications.

B. Required Provisions:

1. All working points indicated on the Construction Drawings shall be adhered to in the detailing of the work.
2. Substitutions of sections shall be made only in accordance with requirements for revision of Construction Drawings.
3. Provide holes required for securing other work to structural steel framing, and for passage of other work through steel framing members.
4. Detail and fabricate work with suitable drain and vent holes as required to provide positive drainage and to prevent the trapping of moisture and stagnant air.

C. Connections:

1. Connections shall be as indicated and as specified herein.
2. Furnish all bolts and bolt placement lists for field and shop connections, including all temporary carbon steel erection bolts and clips required for field erection.
3. Except as otherwise indicated, all connections shall be shop welded and field bolted. Field welded connections will be permitted only where indicated on the Construction Drawings or where specifically approved by the Contractor’s engineer in writing.
4. Bolted connections shall be made with 3/4-inch or 7/8-inch diameter high-strength bolts conforming to ASTM A325 as specified, unless otherwise indicated. Tapered washers shall be provided on bolted connections to channels and other structural shapes with sloping flanges.
5. Framed beam connections, which are not detailed or otherwise indicated shall be shop welded and field bolted in accordance with AISC 325, All-Welded Double-Angle Connections, Table 10-1. Typically, Construction Drawings shall indicate the number of rows of field bolts to be provided; otherwise, connection shall be detailed using the maximum possible number of rows of 3/4-inch diameter bolts as shown in Table 10-1for each beam depth, with minimum connection angles 5/16-inch thick, and using shop weld to provide the same strength of the bolted end.

6. Detail field splice connections to develop the full strength of the section in which the splice is made.
7. All joints made with high strength bolts shall be considered to be bearing-type connections with threads included in the plane of shear, except moment-resisting joints and connection joints where slip-critical type high-strength bolts are required.

2.3 FABRICATION

A. Structural steelwork shall conform to the applicable requirements of the California Building Code, AISC 360 and AASHTO S2.1. Structural steelwork for railroad and high-speed rail bridges shall conform to applicable requirements of the AREMA Manual and AASHTO S2.1.

B. Welding and welded connections shall conform to the requirements of Section 05 05 22, Metal Welding and AWS D1.1, AWS D1.5, AWS D1.8, and AREMA Chapter 15, as applicable to the work.

C. Steel members and metal fabrications shall be prefabricated and preassembled in the factory or shop as far as practicable.

D. Form and fabricate the work to meet installation conditions. Include accessories to adequately secure the work in place.

E. Cutting, drilling, punching, and welding shall be neatly performed with burrs and rough edges removed. Remove all weld flux.

F. Straighten rolled material, if necessary, before it is laid out for fabrication, in a manner conforming to the mill tolerances specified in ASTM A6/A6M, and by a process and in a manner which will not injure the material. Sharp kinks and bends will be cause for rejection of the material. Heat shrinking of low-alloy structural steel will not be permitted.

G. Perform shearing, flame cutting, and chipping carefully and accurately so as not to induce residual stress in the metal being cut. The radii of re-entrant gas-cut fillets shall be not less than 3/4 inch and as much larger as practicable. Perform flame cutting in such manner that metal being cut is not carrying stress. Cut edges exposed in the finished work shall be machine cut, sheared, or flame cut, and ground flush. All working points shall be maintained.

H. Fabricate bearing stiffeners and stiffeners intended as supports for concentrated loads as indicated. Mill or grind bearing surfaces of these stiffeners.

I. Bend load-carrying cold-rolled steel plates cold at right angles to the direction of rolling. The radius of bend, measured to the concave face of the metal, shall be not less than indicated in the following table, in which T is the thickness of the plate.

Angle Through Which Plate is Bent	Minimum Radius
61 to 120 degrees	2.0 T
121 to 150 degrees	3.0 T

1. If a shorter radius is indicated, bend the plate hot. Before bending, round plate edges, where bending occurs, to a radius of 1/16 inch.

J. Connections shall be bolted or welded as indicated.

K. Holes shall be drilled or punched at right angles to the surface of the metal and shall not be made or enlarged by burning. Holes in base or bearing plates shall be drilled. Holes shall be provided in members to permit connecting the work of other trades. Holes shall be punched or drilled at 1/16 inch larger than the diameter of the bolt.

L. For high-strength bolting, assemble joints and install bolts in accordance with AISC 348. Hardened-face washers shall be used for all connections using ASTM A490 bolts. Assembly of joints using load-indicator washers shall conform to ASTM F959. High-strength bolting shall be inspected by a qualified inspector employed by the Contractor's testing laboratory.

M. For items bearing on concrete, provide steel bearing plates and anchors as indicated. Base or bearing plates shall be leveled by means of adjustment nuts. Templates shall be furnished, together with instructions for setting of anchors, anchor bolts, and bearing plates. Contractor shall ensure that anchors and related items are properly set in concrete during the progress of the work.

N. Fabricate metal bearing surfaces which will come in contact with preformed elastomeric bearing pads or grout, flat to within 1/8 inch tolerance in 12 inches and to within 3/16 inch overall.

O. Include reinforcing angles, clip angles, plates, punched straps, brackets, and hangers as required to complete the work as indicated.

P. Provide drainage holes in structural components where water may accumulate without escape.

Q. Fabricate architecturally exposed structural steel members straight within one-half of the standard camber and sweep tolerances permitted by ASTM A6/A6M.

2.4 CLEANING AND PAINTING

A. Interior, Non-Corrosive Applications:

1. After fabrication and immediately before shop painting, structural steel materials shall be washed with solvent to remove dust and residue in accordance with SSPC-SP 1.
    a. Structural steel materials not exposed to the public shall be power-tool cleaned in accordance with SSPC-SP 3 to remove mill scale, rust, grease, oil, and other foreign matter.
    b. Structural steel materials exposed to public view shall be blast cleaned in accordance with SSPC-SP 10 or power-tool cleaned in accordance with SSPC-SP 11 to remove all visible mill scale, rust, grease, oil, and other foreign matter.

2. If materials are not painted immediately after cleaning then those materials shall be washed with solvent to remove dust and residue in accordance with SSPC SP 1.
3. After preparation, steel materials shall be shop painted with one coat of corrosion-inhibitive metal primer in accordance with SSPC PA 1. Materials and application shall conform to SSPC-Paint 20 or SSPC-Paint 22.

B. Exterior Applications:

1. Steelwork to be exposed to weather shall be blast cleaned in accordance with SSPC-SP 10 or power-tool cleaned in accordance with SSPC-SP 11.

2. After cleaning, solvent wash in accordance with SSPC-SP 1, and shop paint steelwork in accordance with SSPC-PA 1. Materials and application shall conform to SSPC-Paint 20.
3. Where steel components are indicated to be galvanized, comply with galvanizing requirements of Section 05 50 00, Metal Fabrications.

C. Steel Materials to Receive Spray-Applied Fireproofing:

1. Steel materials shall be power-tool cleaned in accordance with SSPC-SP 3 to remove mill scale, rust, grease, oil, and any other foreign matter. Welds shall thoroughly wire brushed.
2. After cleaning and just before delivery of steel to the jobsite, steel materials shall be washed with solvent to remove dust and residue in accordance with SSPC-SP 1.
3. Steel materials to receive spray-applied fireproofing shall be shop painted with a primer if recommended by the manufacturer of the fireproofing material.

D. Steel Materials to Receive Intumescent Fireproofing:

1. Interior steel materials shall be power-tool cleaned in accordance with SSPC-SP 3 to remove mill scale, rust, grease, oil, and other foreign matter. Welds shall be thoroughly wire brushed.
2. Exterior steel materials shall be blast cleaned in accordance with SSPC-SP 6 to remove visible mill scale, rust, grease, oil, and other foreign matter. After cleaning and just before delivery of steel to the jobsite, steel materials shall be washed with solvent to remove dust and residue in accordance with SSPC-SP 1.
3. Primer to be shop applied shall be as recommended by the manufacturer of the intumescent fireproofing material.

PART 3 - EXECUTION

3.1 ERECTION AND INSTALLATION

A. Reference Standards: Erection and installation of structural steel shall conform to the applicable requirements of AISC 303, AASHTO S10.1, and AISC 360. Erection and installation of structural steel for railroad and high-speed rail bridges shall conform to applicable requirements of AREMA Manual and AASHTO S10.1.

B. Lines and Levels: Structural steel shall be installed accurately at established lines and levels. Steel shall be plumb and level before bolting is commenced. Installation shall be in accordance with approved shop drawings and actual conditions, true and horizontal or perpendicular as the case may be, level and square, with angles and edges parallel with related lines of the building or structure.

C. Temporary Bracing: Temporary bracing shall be provided as required and shall be kept in position until final completion. Shop fabricated items subject to damage shall be braced and carefully handled to prevent distortions or other damage. All items installed before concrete is placed shall be properly braced to prevent distortion by pressure of concrete. Bracing shall be watched and maintained by the Contractor during concreting operations.

D. Anchors, Anchor Bolts, Studs, and Fasteners:

1. Shop connections shall be welded and field connections bolted, unless indicated otherwise. Use washers under bolt heads and nuts to give full grip when nuts are turned tight. Use beveled washers where bolts bear on sloping surfaces.
2. Anchors, bolts and washers, inserts, studs, and fasteners as required for the erection, installation, and completion of the work, and other miscellaneous steel or iron fastenings to be installed in forms before concrete placement, or built into concrete, shall be provided as indicated at the time scheduled for this work.
3. Bolts and anchors shall be preset by the use of templates or such other methods as may be required to locate the anchors and anchor bolts accurately.

E. Bases and Bearing Plates: Bases and plates which require grouting shall be supported at the correct level by means of adjustment nuts on anchor bolts. Bases and plates shall be set accurately using a high-strength, non-shrink grouting mortar as specified in Section 03 62 00, Non-Shrink Grouting.

F. Erection and Assembly:

1. After erection and field assembly, the various members forming parts of the completed structure shall be aligned and adjusted accurately before being fastened. Tolerances shall conform to the applicable requirements of AISC 303 and AASHTO S10.1.
2. Fastening of splices of compression members shall be performed after the abutting surfaces have been brought into contact. Bearing surfaces and surfaces, which will be in permanent contact, shall be cleaned before the members are assembled. Splices will be permitted only where indicated.
3. Unless removal is required, erection bolts used in welded construction may be tightened securely and left in place. If erection bolts are removed, the holes shall be filled with plug welds and ground smooth. Poor matching of holes shall be corrected by drilling to the next larger size and providing the next larger size bolt. Welding for redrilling will not be permitted.
4. For moment-resisting joints with flanges or combined flange-reinforcing plates 1-1/2 inches thick or thicker, web bolts shall not be tightened past snug-tight until after completion of joint penetration welds.

G. Driftpins: Driftpins may be used only to bring together the several parts or components. Fit-up bolts and driftpins shall not be used to bring out-of-tolerance fabricated members and components into alignment. Driftpins shall not be used with such force as to distort or damage the material.

H. Gas Cutting: The use of a gas-cutting torch in the field for correcting fabrication errors will not be permitted.

I. Bolting:

1. Bolts shall be driven accurately into holes without damaging the thread. Bolt heads shall be protected from damage during driving. Washers shall be placed under all bolt heads and nuts. Bolt heads and nuts shall rest squarely against the washers.
2. Where bolts are to be used on beveled surfaces having slopes greater than 1 in 20 with a plane normal to the bolt axis, beveled washers shall be provided to give full bearing to the head or nut. Bolt threads shall be upset or spoiled to prevent the nuts from backing off.
3. Bolts transmitting shear shall be threaded to such a length that not more than one thread will be within the grip of the metal.

4. Bolts shall extend through but not more than 1/4 inch beyond the nuts, unless otherwise indicated. Bolt heads and nuts shall be drawn tight against the work with a suitable wrench not less than 15 inches long. Bolt heads shall be tapped with a hammer while the nut is being tightened. After having been finally tightened, nuts shall be locked by upsetting or spoiling the threads as close as possible to the nut face and to a depth of penetration necessary to deform one or more threads on the bolt.

J. High-Strength Bolting:

1. Assemble joints in accordance with AISC 348.
2. Tighten bolts to their proof loads with calibrated impact wrenches to a torque not less than recommended for the size of the bolt.
3. Assembly of joints using load-indicator washers shall conform to ASTM F959.
4. Contact surfaces of joints shall be free of paint, lacquer, or other friction-reducing coatings.

K. Sliding Joints: Properly clean sliding-joint assembly bearing surfaces and lubricate as required.

3.2 FIELD QUALITY CONTROL

A. Field-assembled and installed high-strength bolting shall be inspected and torque-tested in accordance with AISC 348 by a qualified inspector selected and paid for by the Contractor.

3.3 FIELD PAINTING

A. After installation of structural steelwork, abraded areas, field bolts, and welds shall be touched up and spot painted with the same corrosion-inhibitive primer as was used for shop painting in accordance with SSPC-PA 1. Field welds shall be thoroughly wire-brushed or disc-sanded prior to touch-up painting.

B. Steel to receive spray-applied fireproofing shall not be touch-up painted.

C. Steel to receive intumescent fireproofing shall be touch-up painted in accordance with the requirements of the intumescent fireproofing manufacturer.

D. Final field painting of exposed structural steel shall be as specified in the Construction Specifications, Division 09, Finishes.

END OF SECTION

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SECTION 05 50 00

METAL FABRICATIONS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Gratings.

B. Metal Walkways.

C. Trench Drains.

D. Ladders.

E. Steel Clips, Angles, Tubes, Pipes and Shapes.

F. Anchors and Bolts.

G. Galvanizing of Steel and Ferrous Metal Items.

1.2 RELATED SECTIONS

A. Refer to the work under Division 32, Exterior Improvements, and Division 33, Utilities, for curb and gutter inlets, catch-basin gratings, manhole covers, and other metalwork associated with, or embedded in, concrete utility structures.

1.3 REFERENCE STANDARDS

A. ASTM International (ASTM):

1.	ASTM A27	Standard Specification for Steel Castings, Carbon, for General Application
2.	ASTM A36	Standard Specification for Carbon Structural Steel
3.	ASTM A47	Standard Specification for Ferritic Malleable Iron Castings
4.	ASTM A48	Standard Specification for Gray Iron Castings
5.	ASTM A53	Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
6.	ASTM A123	Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
7.	ASTM A143	Standard Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement
8.	ASTM A153	Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
9.	ASTM A242/A242M	Standard Specification for High-Strength Low-Alloy Structural Steel
10.	ASTM A307	Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile

11.	ASTM A384	Standard Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies
12.	ASTM A385	Standard Practice for Providing High-Quality Zinc Coatings (Hot-Dip)
13.	ASTM A449	Standard Specification for Hex Cap Screws, Bolts and Studs, Steel, Heat Treated, 120/105/90 ksi Minimum Tensile Strength, General Use
14.	ASTM A500	Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
15.	ASTM A501	Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing
16.	ASTM A514/A514M	Standard Specification for High-Yield-Strength, Quenched and Tempered Alloy Steel Plate, Suitable for Welding
17.	ASTM A536	Standard Specifications for Ductile Iron Castings
18.	ASTM A563	Standard Specification for Carbon and Alloy Steel Nuts
19.	ASTM A572	Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel
20.	ASTM A668	Standard Specification for Steel Forgings, Carbon and Alloy, for General Industrial Use
21.	ASTM A780	Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
22.	ASTM A913	Standard Specification for High-Strength Low-Alloy Steel Shapes of Structural quality, Produced by Quenching and Self-tempering Process (QST)
23.	ASTM A992	Standard Specification for Steel for Structural Shapes
24.	ASTM D6386	Standard Practices for Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Product and Hardware Surfaces for Painting
25.	ASTM F436	Standard Specification for Hardened Steel Washers

B. National Association of Architectural Metal Manufacturers (NAAMM):

1. Metal Bar Grating Manual

C. Society for Protective Coatings (SSPC):

1.	SSPC-SP 1	Solvent Cleaning
2.	SSPC-SP 3	Power Tool Cleaning
3.	SSPC-PA 1	Shop, Field and Maintenance Painting for Steel
4.	SSPC-Paint 20	Zinc-Rich Primers, Type I - Inorganic and Type II - Organic
5.	SSPC-Paint 22	Epoxy-Polyamide Paints (Primers, Intermediate and Topcoat)

1.4 SUBMITTALS

A. Shop Drawings: Submit fully detailed shop drawings of metal fabrications and miscellaneous metalwork, showing sizes, details of fabrication and construction, methods of assembly, locations of hardware, anchors, and accessories, and installation details.

1. Detailing Requirements: Detail steel components as specified in Section 05 12 00, Structural Steel Framing, and items to be galvanized in accordance with applicable requirements of ASTM A384 and ASTM A385. Detail and fabricate work with suitable drain and vent holes to provide positive drainage and to prevent trapping of moisture and stagnant air.

B. Product Data: Submit manufacturers' product data of all manufactured items and products.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General: Manufactured steel clips and angles will be accepted where such will meet the requirements of the Construction Drawings and are shown on approved shop drawings.

B. Steel Materials:

1. Shapes: Standard structural shapes of M, S, C, and MC sections, plates, and bars as indicated, conforming to ASTM A36. Bars conforming to ASTM A242 or ASTM A514 will be accepted.
2. W- Shapes: Wide-flange sections, as indicated, conforming to ASTM A992 Grade 50, ASTM A572 or ASTM A913 as applicable to the work.
3. HP Shapes: HP sections, as indicated, conforming to ASTM A572 Grade 50, ASTM A572 or ASTM A913 as applicable to the work.
4. Tubing: Steel tubing, conforming to ASTM A500 Grade B or ASTM A501, of size and shape indicated.
5. Pipe: Steel pipe or round tubing, conforming to ASTM A53 Grade B, of diameters and sizes indicated. Pipe for sleeves and exterior locations shall be galvanized pipe as specified in ASTM A53.

C. Welding Rods/Electrodes: Refer to Section 05 05 22, Metal Welding, for requirements.

D. Castings: ASTM A27, ASTM A47, ASTM A48, or ASTM A536, as applicable to the work.

E. Forgings: ASTM A668, of Class indicated or required.

F. Anchors and Bolts: ASTM A307, ASTM A449, ASTM A563, and ASTM F436, as applicable. Bolts and studs, nuts, and washers shall be hot-dip galvanized in accordance with ASTM A153.

G. Fasteners and Accessories: Furnish anchors and fasteners, washers, straps, and accessories as required for a complete and finished installation. Fasteners shall be stainless steel or galvanized steel as appropriate and approved by the Contractor’s engineer for the location.

H. Concrete and Masonry Anchors: Where anchors are not cast into the concrete or masonry construction, provide galvanized expansion type anchors with matching galvanized steel bolts or studs with nuts, of sizes as indicated or required. Provide washers under all bolt heads and nuts.

I. Gratings:

1. Bar-Type Gratings:
   a. Provide flat-bar type steel gratings of all-welded construction, consisting of bearing bars and secondary bars in rectangular configuration, with flat/plane level traffic surface, hot-dip galvanized after fabrication. Provide gratings with matching hot-dip galvanized steel frames for anchoring in concrete. Comply with applicable requirements of NAAMM "Metal Bar Grating Manual."
   b. Notch or frame openings in gratings for penetrations as indicated. Lay out units to allow grating removal without disturbing items penetrating the grating. Provide

banding for openings in grating separated by more than four bearing bars, of same material and size as bearing bars.

c. Cut, drill, and fit gratings as required for installation. Notching of bearing bars to provide supports for maintaining elevations will not be permitted.

2. Perforated Sheet Gratings:

a. Provide perforated sheet gratings fabricated from button-embossed structural steel sheet of minimum 12-gage thickness, with punched circular holes at apex of buttons for nonslip effect, and punched circular holes between buttons for drainage. Buttons shall be spaced 5/8 inch on centers. Drainage holes shall be spaced 1-1/4 inches on centers, eliminating the buttons at these locations. Hole size for button holes shall be 1/8-inch diameter, plus or minus 1/32 inch. Hole size for drainage holes shall be 1/4-inch diameter, plus or minus 1/16 inch.

b. Supporting edges shall be channel- or U-shaped, formed edges capable of supporting a uniform live load of 300 pounds per square foot and a concentrated load of 3,000 pounds. Provide additional reinforcing as necessary to support the specified loads.

c. Provide gratings with matching steel frames for anchoring in concrete. Provide frames with appropriate concrete anchors.

d. Gratings and frames shall be hot-dip galvanized after fabrication in accordance with ASTM A123.

J. Metal Walkways:

1. Provide metal walkways where indicated, fabricated from checkered or diamond-pattern steel plate or from button-embossed structural steel sheet as specified above for perforated sheet gratings.
2. Walkway panels shall be of sizes and plate or sheet thickness indicated, cut or formed to shape and configuration indicated. Walkway panels shall be removable where they serve as covers for wireways and trenches. Provide removable panels/covers with matching steel frames for anchoring in concrete. Provide hinges, chains, and related opening hardware as indicated for wireway covers. All hardware items shall be 300 series stainless steel or galvanized after fabrication.
3. Walkway panels shall be capable of supporting a uniform live load of 150 pounds per square foot and a concentrated load of 1,500 pounds.
4. Walkway panels and frames, including supporting and reinforcing components and accessories, shall be hot-dip galvanized after fabrication in accordance with ASTM A123.
5. When checkered or diamond-pattern steel plate is provided for walkway panels, coat panels with nonslip encapsulated aluminum oxide material bonded or fused to the steel surface. Submit product data and sample.

K. Trench Drains:

1. Provide standard manufactured trench frames with grated or solid covers, as indicated, of sizes and configurations indicated. Trench drains/frames and covers shall be manufactured of gray iron conforming to ASTM A48 or ductile iron conforming to ASTM A536 or a combination of both. Provide heavy-duty type.
2. Provide covers with machined bearing surfaces to prevent rocking and rattling.
3. Where pedestrian traffic will travel over trench drains, provide covers with nonslip surface.
4. That portion of trench drains/frames to be in contact with concrete, earth or fill, shall be coated with bituminous emulsion.

L. Ladders:

1. Provide standard-manufactured or custom-fabricated steel ladders as required to meet the conditions indicated. Steel ladders shall be hot-dip galvanized after fabrication. Ladders may be anodized aluminum where not required to serve as a fire exit.
2. Ship's ladders shall be provided with railings and handrails. Vertical ladders exceeding 10 feet in height shall be provided with safety cages.

M. Grout: Provide high-strength, non-shrink grout for base plates and bearing plates in accordance with the requirements of Section 03 62 00, Non-Shrink Grouting, and Section 05 12 00, Structural Steel Framing, as applicable.

N. Paint: Corrosion-inhibitive protective metal primer as herein specified under “Cleaning and Painting”.

2.2 FABRICATION

A. Metalwork shall be fabricated by firms or shops experienced and skilled in the custom fabrication and construction of metal fabrications and miscellaneous metalwork. There shall be no exposed screws, bolts, and fasteners in the finished work, except as indicated or required.

B. Welded connections shall be made in accordance with requirements of Section 05 05 22, Metal Welding. Welds where exposed to view shall be ground and dressed smooth, so that the shape and profile of the item welded is maintained.

C. Metal fabrications shall be prefabricated and preassembled in the factory or shop as far as practicable.

D. Form and fabricate the work to meet installation conditions. Include anchors, fasteners, and accessories to secure the work in place, as indicated.

E. The Contractor may furnish standard manufactured products for components when applicable, providing such products meet space limitations and installation conditions and are approved by the Contractor’s engineer.

2.3 GALVANIZING

A. Steel and ferrous metal items on the exterior of buildings, items exposed to the weather and moisture, gratings, and items specifically indicated, shall be galvanized after fabrication by the hot-dip process in accordance with ASTM A123. Weight of the zinc coating shall conform to the requirements specified under "Weight of Coating" in ASTM A123. Provide high-quality galvanizing in conformance with ASTM A385.

1. Seal-weld Overlapping Surfaces: Remove all weld flux. Plug vents provided in seal-welded overlapping surfaces to prevent entry of pickling acids. Remove such plugs before galvanizing.

B. Safeguarding against steel embrittlement shall conform to the applicable requirements of ASTM A143.

C. Safeguarding against warpage and distortion of steel members shall conform to the applicable requirements of ASTM A384.

D. Shop galvanized metalwork necessitating field welding which in any manner removes original galvanizing shall be restored by field galvanizing repair in accordance with ASTM A780.

E. Bolts and screws for attachment of galvanized items shall be galvanized in accordance with ASTM A153.

2.4 CLEANING AND PAINTING

A. Nongalvanized Metalwork:

1. After fabrication and immediately before shop painting, ferrous metalwork shall be power-tool cleaned in accordance with SSPC-SP 3 to remove mill scale, rust, grease, oil, and any other foreign matter. Welds shall be thoroughly wire brushed.
2. After power-tool cleaning and just before shop painting, ferrous metalwork shall be washed with solvent to remove dust and residue in accordance with SSPC-SP 1.
3. After cleaning and solvent washing, ferrous metalwork shall be shop painted with one coat of corrosion-inhibitive metal primer in accordance with SSPC-PA 1. Materials and application shall conform to SSPC-Paint 20 or SSPC-Paint 22.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install metal fabrications and miscellaneous metalwork as indicated and in accordance with the approved shop drawings, using workers skilled and experienced in the installation of the type of work involved.

B. Install metal fabrications and miscellaneous metalwork with all installation accessories furnished by the fabricator as required for complete and finished installations.

C. Installation of metalwork shall be in accordance with approved shop drawings, true and horizontal, perpendicular, or at the required angle, as the case may be, level and square, with angles and edges parallel with related lines of the building or structure.

D. Field welding, where indicated, shall conform to requirements of Section 05 05 22, Metal Welding.

E. Where bases and bearing plates require grouting, conform to requirements of Section 03 62 00, Non-Shrink Grouting, and Section 05 12 00, Structural Steel Framing, as applicable.

3.2 GALVANIZING REPAIR

A. Galvanized surfaces, which have become damaged from welding, handling, or installation, shall be repaired immediately after installation with galvanizing repair material in accordance with ASTM A780.

3.3 FIELD PAINTING

A. After installation, exposed painted surfaces, field welds, and other abraded or damaged primed surfaces shall be prepared as required and touched up with an additional coat of the same primers for ferrous and galvanized surfaces as herein- before specified for shop painting. Spray-paint all touch-up work.

B. Finish field painting, where required, shall be as specified in the Construction Specifications, Division 09, Finishes.

END OF SECTION

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SECTION 05 51 00

METAL STAIRS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Concrete-filled Pan Stairs.

B. Industrial Type Stairs.

C. Safety Tread Stairs.

D. Railing System.

E. Design of stairs and railings.

1.2 RELATED SECTIONS

A. Section 05 05 22, Metal Welding.

1.3 REFERENCE STANDARDS

A. American Concrete Institute (ACI):

1.	ACI117	Standard Specifications for Tolerances for Concrete Construction and Materials and Commentary
2.	ACI 301	Standard Specifications for Structural Concrete

B. ASTM International (ASTM):

1.	ASTM A36/A36M	Standard Specification for Carbon Structural Steel
2.	ASTM A53	Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc- Coated, Welded and Seamless
3.	ASTM A123	Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
4.	ASTM A153	Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
5.	ASTM A307	Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength
6.	ASTM A370	Standard Test Methods and Definitions for Mechanical Testing of Steel Products
7.	ASTM A500	Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
8.	ASTM A501	Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing
9.	ASTM A780/A780M	Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
10.	ASTM A1008/A1008M	Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy

		with Improved Formability, Solution Hardened, and Bake Hardenable
11.	ASTM C33	Standard Specification for Concrete Aggregates
12.	ASTM E894	Standard Test Method for Anchorage of Permanent Metal Railing Systems and Rails for Buildings
13.	ASTM E935	Standard Test Methods for Performance of Permanent Metal Railing Systems and Rails for Buildings
14.	ASTM E985	Standard Specification for Permanent Metal Railing Systems and Rails for Building

C. Society for Protective Coatings (SSPC):

1.	SSPC-PA1	Shop, Field and Maintenance Painting of Steel
2.	SSPC-SP 1	Solvent Cleaning
3.	SSPC-SP 3	Power Tool Cleaning
4.	SSPC-SP 10	Near-White Blast Cleaning
5.	SSPC-SP 11	Power Tool Cleaning to Bare Metal

1.4 SUBMITTALS

A. Stair Design: Stairs, except as otherwise designed and shown on contract documents, shall be designed and engineered by the manufacturer, incorporating specified criteria, and employing a professional civil or structural engineer currently registered in the State of California to perform the design engineering. Include design data along with shop drawings. Drawings and design data shall be stamped and signed by the manufacturer's professional engineer.

1. Indicate materials and detailing of contrasting stripe.

B. Shop Drawings: Submit fully detailed shop drawings of metal stairs and railings, showing sizes, details of fabrication and construction, methods of assembly, handrail brackets, locations of hardware, anchors, and accessories, and installation details.

C. Product Data: Submit manufacturer’s product data of stair type and corrosion-inhibitive primer and finish system. Include patterned or embossed treads, safety coated treads, railing system, handrails, and handrail brackets.

1.5 REGULATORY REQUIREMENT

A. Design and construct stairs and railings in compliance with applicable codes.

B. Comply with California Building Code, including Chapter 11B, Accessibility to Public Buildings, Public Accommodations, Commercial Buildings, and Publicly Funded Housing.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Type and Manufacture: Provide steel stairs of the following types as indicated:

1. Concrete-Filled Pan Stairs: Steel pan-type stairs with concrete-filled treads and landings, and with treads, risers, and platforms constructed fron structural steel sheet. Treads shall have nosings.

2. Industrial Type Stairs: Steel stairs with tread fabricated from checkered or diamond-pattern steel plate or sheet, or with treads fabricated from button-embossed structural steel sheet. Risers shall be closed, fabricated from steel sheet.
3. Safety Tread Stairs: Steel stairs with formed steel treads and platforms, coated with anti-skid safety surface, and closed steel sheet risers.
4. Railing System: All stairs shall be provided with a complete stair railing system, including guardrails, handrails and handrail brackets at walls, fabricated from steel pipe.

B. Stringers and Supporting Steel:

1. Structural Shapes: Standard structural sections M, S, C, MC, and L, as indicated, conforming to ASTM A36/A36M.
2. Structural Tubing (HSS): Seamless steel tubing, conforming to ASTM A500 Grade B or ASTM A501, Grade 36, of size and shape indicated.

C. Treads and Risers, Platforms and Landings:

1. Steel Sheet: Treads, risers, and platforms shall be fabricated from structural steel sheet, of gage or thickness indicated, conforming to ASTM A1008/A1008A, Grade 33, with minimum yield point of 33,000 psi, formed as indicated. When gage is not indicated, provide 14 gage steel sheet.
2. Patterned Steel Plate: Treads and platforms for industrial-type closed-riser stairs shall be commercial quality checkered or diamond-pattern steel plate or structural steel sheet of thickness indicated, formed to shape and configuration indicated. Risers shall be steel sheet as specified above. Treads and platforms shall be hot-dip galvanized after fabrication in accordance with ASTM A123.
   a. Button-Embossed Steel Sheet: Treads and platforms may be fabricated from button-embossed structural steel sheet of minimum 12 gage thickness, with punched circular holes at apex of buttons for nonslip effect, and punched circular holes between buttons for drainage. Buttons shall be spaced 5/8 inch on centers. Drainage holes shall be spaced 1-1/4 inches on centers, eliminating the buttons at these locations. Hole size for button holes shall be 1/8-inch diameter, plus or minus 1/32 inch. Hole size for drainage holes shall be 1/4-inch diameter, plus or minus 1/16 inch. Treads and platforms shall be hot-dip galvanized after fabrication in accordance with ASTM A123.

3. Safety Coated Treads: Formed steel sheet coated with anti-skid or nonslip encapsulated aluminum oxide material bonded or fused to the steel surface. Submit product data and sample.

D. Railings and Handrails:

1. Pipe: Pipe for railings, pipe supports, and handrails shall be seamless steel pipe conforming to ASTM A53, Grade B, of diameters and sizes indicated.
2. Handrail Brackets: Provide handrail brackets for handrails at walls, manufactured specifically for the purpose of cast, forged, or wrought steel, of configuration indicated or required to suit conditions, galvanized after fabrication.

E. Welding Rod/Electrodes: Refer to Section 05 05 22, Metal Welding, for requirements.

F. Anchors, Fasteners, and Accessories: Provide all required anchors, fasteners, miscellaneous components, and accessories as required for a complete and finished stair installation. Bolts, nuts, and washers shall conform to ASTM A307, galvanized in accordance with ASTM A153.

1. Expansion Bolts: Where anchors are not cast into the concrete construction, provide galvanized expansion type anchors with matching galvanized steel bolts or studs with nuts, of sizes as indicated or required. Provide washers under all bolt heads and nuts. Expansion bolts require approval of the Contractor’s engineer before they may be installed in post-tensioned slabs. Expansion bolts will not be permitted for use on concrete curbs or along the edge of concrete or a concrete joint.

G. Paint: Corrosion-inhibitive protective primer as specified in Article entitled “Cleaning and Painting” herein.

H. Grout: Refer to Section 03 62 00, Non-Shrink Grouting, for requirements.

2.2 DESIGN CRITERIA – STRUCTURAL REQUIREMENTS

A. Design and fabricate stair and railing assemblies to meet building code requirements, including live load requirements.

2.3 FABRICATION

A. Metal stairs and railings shall be fabricated by firms or shops experienced and skilled in the construction of metal stairs and architectural railings. There shall be no exposed screws, bolts, and fasteners in the finished work.

B. For items bearing on concrete, provide steel bearing plates and anchors as indicated or required. Base or bearing plates shall be leveled by means of adjustment nuts. The space below plates shall be packed solid with full bed of non-shrink grout. Templates shall be furnished, together with instructions for setting of anchors, anchor rods, and bearing plates. The Contractor shall supervise and ensure that anchors and related items are properly set in concrete during the progress of the work.

C. Welded connections shall be made in accordance with applicable requirements of Section 05 05 22, Metal Welding. Welding shall be performed in the shop, unless otherwise indicated. Welds where exposed to view shall be ground down and dressed smooth, so that the shape and profile of the item welded are maintained.

D. Holes shall be cut, drilled, or punched at right angles to the surface of the metal and shall not be made or enlarged by burning. Holes in base or bearing plates shall be drilled. Holes shall be provided in members as required to permit connecting the work of other trades.

E. Metal stairs and railings shall be prefabricated and preassembled in the factory or shop as far as practicable.

2.4 GALVANIZING

A. Except as otherwise indicated stair and stair components, including railing and handrail, shall be hot-dip galvanized after fabrication in accordance with the galvanizing requirements of Section 05 50 00, Metal Fabrications.

2.5 CLEANING AND PAINTING

A. Cleaning and painting shall conform to like requirements specified in Section 05 12 00, Structural Steel Framing.

B. All surfaces of metal stairs and railings, including surfaces of pan-filled stairs, shall be cleaned and treated to assure maximum paint adherence, prior to application of the shop prime coat, in accordance with SSPC-SP 1, SSPC-SP 3, SSPC-SP 10, and SSPC-SP 11 as applicable for the exposure and application.

C. Ferrous metalwork shall be given a shop coat of rust-inhibitive metal primer as specified in Section 05 12 00, Structural Steel Framing, or other approved rust-inhibitive metal primer standard with the stair manufacturer. All surfaces of stairwork and railings shall be spray-painted.

D. Where galvanized surfaces are indicated to be painted, comply with cleaning and painting requirements of Section 05 50 00, Meal Fabrications.

E. Coordinate with appropriate Section of the Construction Specifications, Division 09, Finishes, for compatibility of the prime coat and finish coats of paint.

2.6 CONCRETE

A. Reinforcement for Treads and Landings: Provide wire mesh W1.4xW1.4 - 6x6 minimum in all concrete treads and landings.

B. Concrete for concrete-filled pan stair treads and landings shall be concrete, weighing not less than 120 pounds per cubic foot, with a minimum compressive strength at 28 days of 4,000 psi. Maximum aggregate size shall be 3/8 inch (ASTM C33, Size No. 8). Include a mix of aluminum oxide and silicon carbide grit particles as required to produce non-slip tread surfaces.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Stairs and railings shall be installed by the manufacturer or its authorized representative as indicated and in accordance with the approved shop drawings and the manufacturer's installation instructions. Stairs and railings shall be installed with all accessories furnished by the manufacturer or fabricator as required for complete and finished stair installations.

B. Installation of stair work shall be true and horizontal or perpendicular as the case may be, level and square, with angles and edges parallel with related lines of the building or structure.

C. Shop fabricated items subject to damage shall be braced and carefully handled to prevent distortions or other damage.

D. Field welding, where required, shall conform to requirements specified for shop fabrication.

E. Bearing plates shall be supported at the proper level by means of adjustment nuts on anchor bolts. Bases and plates shall be set accurately using a high-strength, non-shrink grouting mortar to obtain uniform bearing.

3.2 TOUCH-UP AND FIELD PAINTING

A. After installation, exposed painted surfaces, field welds, and other abraded or damaged primed surfaces shall be touched up with an additional coat of the same primer for ferrous surfaces as herein before specified for shop painting. Spray paint all touch-up work.

B. Galvanized surfaces, which have become damaged from welding, handling, or installation, shall be repaired immediately after installation with galvanizing repair material in accordance with ASTM A780.

C. Finish field painting shall be as specified in the Construction Specifications, Division 09, Finishes.

3.3 CONCRETE WORK

A. Concrete for pan-filled stairs shall be placed, compacted, finished, and cured in accordance with applicable requirements of ACI 301.

B. Treads and landings shall receive a "troweled finish" in combination with a "nonslip finish” with “very flat” tolerances as specified in ACI 301 and ACI 117.

3.4 STAIR TYPE LOCATION SCHEDULE

A. Use concrete-filled pan stairs for the following applications: Stairs within shop buildings. Stairs within stations which are used only by employees.

B. Use industrial type and safety tread stairs for the following applications: Emergency egress for shop buildings, equipment access stairs, and maintenance-only access stairs (not used for public emergency egress).

END OF SECTION

SECTION 07 95 63

BRIDGE BEARINGS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Disc bearings.

B. Spherical bearings.

1.2 RELATED SECTIONS

A. Elastomeric bearing pad is specified in Section 03 15 15, Elastomeric Bearing Pads.

1.3 REFERENCE STANDARDS

A. American Association of State Highway and Transportation Officials (AASHTO):

1. AASHTO LRFD Bridge Design Specifications
2. AASHTO LRFD Construction Specifications
3. AASHTO G9.1 Steel Bridge Bearing Design and Detailing Guidelines

B. ASTM International (ASTM):

1. ASTM A709/A709M Standard Specification for Structural Steel for Bridges
2. ASTM A240/A240M Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
3. ASTM B36 Standard specification for Brass Plate, Sheet, Strip, and Rolled Bar

C. American Welding Society (AWS):

1. AWS C2.18 Guide for Protection of Steel with Thermal Sprayed Coating of Aluminum and Zinc and Their Alloys and Composites
2. AWS D1.1 Structural Welding Code – Steel
3. AWS D1.6 Structural Welding Code – Stainless Steel

1.4 SUBMITTALS

A. Shop Drawings: Submit shop drawings for all components and assemblies, including general arrangements and large scale details. The shop drawings shall include tables showing load capacity and movement rating, if applicable, of each bearing, including initial offset required at various ambient temperatures.

B. Calculations: Submit calculations showing conformance of the bearings to the design loadings, movements and other specified requirements.

C. Submit weld procedures.

D. Product bearing sampling and testing.

E. Certificates of Compliance: Submit certificates of compliance certifying that materials and fabrication of bearings comply with these Specifications as applicable.

F. Factory Quality Control Test Procedures and Results: Submit test procedures and results and obtain Contractor's engineer's approval prior to shipment of the bearings to the job site,

1.5 QUALITY ASSURANCE

A. Shop drawings shall be stamped by and calculations shall be performed and sealed a professional civil or structural engineer licensed in the State of California and employed by the bearing supplier with at least 5 years of documented history of bearing design experience.

1.6 IDENTIFICATION, STORAGE AND HANDLING

A. Identification: Each bearing shall be stamped with the manufacturer's name, project identification number, bearing type or model number, bearing number, and the installed location. The stamp shall be on a surface visible after installation.

B. Packaging and Handling: After assembly including sole plates and masonry plates, bearing components shall be held together with steel strapping or other means, to prevent disassembly until the time of installation. Packaging shall be adequate to prevent damage from impact as well as from dust and moisture contamination during shipping and storage. Bearing assemblies shall be handled by their bottom surfaces only. Do not lift bearings by their tops, sides, or shipping bands.

C. Storage: When in storage, the bearings shall be kept banded, wrapped, and secured in a condition suitable for shipment.

D. Bearings delivered to the bridge site shall be stored under cover on a platform above the ground surface. Bearings shall be protected at all times from damage.

PART 2 - PRODUCTS

2.1 TYPES OF BEARINGS AND DEFINITIONS

A. Disc Bearing: A disc bearing functions by deformation of a polyether urethane disc, which shall be stiff enough to resist vertical loads without excessive deformation and yet be flexible enough to accommodate the imposed rotations without liftoff or excessive stress on other components, such as PTFE. The urethane disc shall be positively located to prevent its slipping out of place. The dimensions of the elements of a disc bearing shall be such that hard contact between metal components, which prevents further displacement or rotation, will not occur under the least favorable combination of design displacements and rotations at the strength limit state. The disc bearing shall be design for the design rotation, θ_u, as specified in AASHTO LRFD Bridge Design Specifications, Article 14.4.2. For the purpose of establishing the forces and deformations imposed on a disc bearing, the axis of rotation may be taken as lying in the horizontal plane at mid-height of the disc. The urethane disc shall be held in place by a positive location device. Limiting rings may be used to partially confine the elastomer against lateral expansion. They may consist of steel rings welded to the upper and lower plates or a circular recess in each of those plates. If the limiting ring is used, the depth of the ring shall be at least $0.03D_d$, where D_d is the

diameter of the urethane disc. Based on how the bearing is connected to the superstructure, disc bearing can be classified as fixed bearing, guided expansion bearing or non-guided expansion bearing.

B. Spherical Bearing: The geometry of a spherical bearing controls its ability to resist lateral loads, its moment-rotation behavior, and its frictional characteristics. Spherical bearing shall consist of two metal parts with matching curved surfaces and a low-friction sliding interface consisting of stainless steel or bronze and PTFE. The material properties, characteristics, and frictional properties of the sliding interface shall satisfy the requirement specified in AASHTO LRFD Bridge Design Specifications, Articles 14.7.2 and 14.7.7. The two surfaces of a sliding interface shall have equal nominal radii. The radius of the curved surface shall be large enough to ensure that the maximum average bearing stress, σ_{ss}, on the horizontal projected area of the bearing at the strength limit state shall satisfy the average stress specified in AASHTO LRFD Bridge Design Specifications, Articles 14.7.2.4 and 14.7.7.3. Where bearings are required to resist horizontal loads and the strength limit state or extreme event limit state, an external restraint system shall be provided. Based on how the bearing is connected to the superstructure, spherical bearing can be classified as fixed bearing, guided expansion bearing or non-guided expansion bearing.

2.2 MATERIALS

A. Steel Plate: ASTM A709 Grades 36, 50 or 50W.

B. Stainless Steel: ASTM A240, Type 304 with a minimum No.8 mirror finish.

C. Polytetrafluoroethylene (PTFE): PTFE sheet shall be manufactured from pure virgin unfilled TFE resin conforming to the material requirements of AASHTO LRFD Bridge Construction Specification, Section 18.8.2. PTFE shall be resistant to acids, alkalis and petroleum products: non-absorbing of water, stable from minus 360 degrees F to plus 500 degrees F; and non-flammable. It shall meet all the test requirements as specified.

D. Adhesive: Adhesive used for bonding sheet PTFE shall be epoxy material stable from minus 100 degrees F to plus 250 degrees F.

E. Polyether Urethane: Polyether urethane shall conform to Section 18.3.2.8 and Table 18.3.2.8-1 of the AASHTO LRFD Bridge Construction Specifications.

F. Elastomer: The pot bearing elastomer shall conform to AASHTO LRFD Bridge Construction Specifications, Section 18.3.2.4. The elastomer shall be plain, not laminated or fiber reinforced.

G. Brass for Sealing Rings: ASTM B36, half-hard alloy.

2.3 DESIGN REQUIRMENTS

A. Disc bearings and spherical bearings shall be designed based on the AASHTO LRFD Bridge Design Specification and AASHTO G9.1 Steel Bridge Bearing Design and Detailing Guidelines using loads, rotations and movements given on the Construction Drawings. Design shall assume that vertical and horizontal loads occur simultaneously.

B. The design of the disc bearings shall meet the following additional requirements:

1. The bearing assembly shall be removable and replaceable by raising the bridge superstructure 0.375-inch maximum. This requires the fabrication of a minimum of a four-

plate system including a masonry plate, lower bearing plate, upper bearing plate, and sole plate.

2. The sole and masonry plates shall be designed to distribute the bearing loads into the surrounding substructure or superstructure. Service or installation considerations specified by the Contractor's engineer, such as weldability and bearing height, may require thicker masonry and sole plates than are required due to strength considerations alone.
3. When necessary, guide bars shall be welded to the slide plates or integrally machined into a larger plate. Guide bars shall be designed for the specified horizontal loads, but not less than 10 percent of the vertical capacity of the bearing. Guided members shall have their contact area within the guide bars in all operating positions. The total clearance between guide bars and the guided member shall be 1/16 inch, plus or minus 1/32 inch.
4. The polyether urethane disc shall be designed for a maximum average compressive stress of 5,000 psi. If the outer surface of the disc is not vertical, the stress shall be computed using the smallest plan diameter of the disc, excluding the area of any holes.
5. The shear restriction mechanism shall be designed to allow free rotation and withstand the specified horizontal forces. The mechanism shall be designed to withstand the design forces on the bearing without exceeding the allowable shear, bending, and bearing capacities. Shear resistance of the urethane disc shall not be included.
6. All steel surfaces in contact with PTFE, or other steel surfaces, shall be finished to a smoothness of 125 micro-inches (rms) or less.
7. Stainless steel sheets shall be of 16-gauge minimum thickness and shall be attached to their backing plates by continuous fillet welding along their edges. Bonding or mechanical fastening of sheets shall not be permitted. The attachment of stainless steel sheets to their backing plates shall be capable of resisting the frictional force set up in the bearing. Welding shall be in accordance with AWS D1.6. The backing plates shall extend beyond the edge of the stainless steel sheets to accommodate the welds and the welds shall not protrude above the stainless steel sheets. Stainless steel sheets shall face downward and shall completely cover the PTFE sheets in all operating positions, plus 2 additional inches in the direction(s) of movement. The surfaces in contact with the PTFE shall be finished to a smoothness of 20 micro-inches (rms) or less.
8. PTFE sheets shall be a minimum of 0.125 inch thick, epoxy-bonded into a square-edged recess of a depth equal to one-half of PTFE sheet thickness. The shoulders of the recesses shall be sharp and square. After completion of the bonding operation, the PTFE surfaces shall be smooth and free from blisters and bubbles. Alternative low coefficient of friction materials shall be considered for use on both the guide bars and horizontal sliding surfaces. Materials used on the horizontal sliding surfaces shall be more durable than PTFE with a coefficient of friction similar to PTFE.

2.4 FABRICATION TOLERANCES

A. Disc Bearings

1. Determination of Flatness and Tolerances: Flatness of bearings after welding and fabrication shall be determined by the following method:
    a. A precision straightedge that is longer than the nominal dimension to be measured shall be placed in contact with the plate surface to be measured.
    b. Select a feeler gauge with a thickness corresponding to the flatness tolerances in Item d. below, and having a tolerance of plus or minus 0.001 inch and attempt to insert it under the straightedge.
    c. Flatness is acceptable if the feeler does not pass under the straightedge.
    d. Flatness tolerances are arranged in the following classes:

1) Class A: 0.0005 inch by "Nominal Dimension"
2) Class B: 0.001 inch by "Nominal Dimension"
3) Class C: 0.002 inch by "Nominal Dimension"

e. "Nominal Dimension" shall be interpreted as the actual dimension of the plate, in inches, under the straightedge.

2. Rotational Elements

a. Upper and lower bearing plate tolerances shall be:
   1) Plan dimensions under 30 inches: minus 0 inch, plus 3/16 inch
   2) Plan dimensions over 30 inches: minus 0 inch, plus 1/4 inch
   3) Thickness tolerance shall be: minus 0 inch, plus 1/16 inch
   4) Class "B" tolerance for the side in contact with the urethane disc and Class "A" tolerance for the side in contact with other bearing components.

b. The tolerance on the diameter of the shear restricting pin shall be minus 0 inch, plus 1/16 inch and the tolerance on the diameter of the receiving hole shall be minus 0 inch and plus 3/32 inch.

c. Urethane disc tolerances shall be:
   1) Diameters greater than 20 inches: minus 3/32 inch, plus 3/32 inch
   2) Diameters less than 20 inches: minus 1/16 inch, plus 1/16 inch
   3) Thickness: minus 0 inch, plus 1/8 inch.

3. Non-Rotational Elements

a. Masonry and distribution plate tolerances shall be:
   1) Plan dimensions under 30 inches: minus 0 inch, plus 3/16 inch
   2) Plan dimensions over 30 inches: minus 0 inch, plus 1/4 inch
   3) Thickness tolerance shall be: minus 1/32 inch, plus 1/16 inch
   4) Class "C" tolerance for the underside and Class "A" tolerance for the upper side in contact with other bearing components.

b. Sole plates shall conform to:
   1) Plan dimensions under 30 inches: minus 0 inch, plus 3/16 inch
   2) Plan dimensions over 30 inches: minus 0 inch, plus 1/4 inch
   3) Center line thickness: minus 1/32 inch, plus 1/8 inch
   4) Bevel (if required): plus or minus 0.002 radian
   5) Class "B" tolerance for the upper side and Class "A" tolerance for the underside (i.e., side contacting stainless-steel sliding surface) in contact with other bearing components.

c. Guide bar tolerance shall be:
   1) Length: plus or minus 1/8 inch
   2) Section dimensions: plus or minus 1/16 inch
   3) Flatness where it bears on another plate: Class "A"
   4) Bar-to-bar, nominal dimension: plus or minus 1/16 inch and not more than 1/16 inch out of parallel.

d. Overall bearing height shall not vary from nominal height dimension by more than plus 1/4 inch or less than minus 1/16 inch.

B. Spherical Bearings

1. Determination of Flatness and Tolerances: Flatness of bearings after welding and fabrication shall be determined by the following method:

a. A precision straightedge that is longer than the nominal dimension to be measured shall be placed in contact with the plate surface to be measured.

b. Select a feeler gauge with a thickness corresponding to the flatness tolerances in Item d. below, and having a tolerance of plus or minus 0.001 inch and attempt to insert it under the straightedge.
c. Flatness is acceptable if the feeler does not pass under the straightedge.
d. Flatness tolerances are arranged in the following classes:
   1) Class A: 0.0005 inch by “Nominal Dimension”
   2) Class B: 0.001 inch by “Nominal Dimension”
   3) Class C: 0.002 inch by “Nominal Dimension”
e. “Nominal Dimension” shall be interpreted as the actual dimension of the plate, in inches, under the straightedge.

2. Rotational Elements
   a. Concave and convex spherical plate tolerances shall be:
      1) Plan dimensions under 30 inches: minus 0 inch, plus 3/16 inch
      2) Plan dimensions over 30 inches: minus 0 inch, plus 1/4 inch
      3) Thickness tolerance shall be: minus 0 inch, plus 1/16 inch
      4) Class “A” tolerance for the side in contact with the stainless steel, PTFE or bronze surface and for the side in contact with other bearing components.
   b. The tolerance on the radius of the convex and concave surfaces shall be: minus 0 inch, plus 1/4 inch. The radius of the curved surface shall be large enough to ensure that the maximum average bearing stress, σ_{ss}, on the horizontal projected area of the bearing at the strength limit state shall satisfy the average stress specified in AASHTO LRFD Bridge Design Specifications, Articles 14.7.2.4 or 14.7.7.3.
   c. The radius of the sliding surfaces for the convex and concave plates shall be equal. The tolerance of difference for the radius between the curve surfaces shall be plus or minus 0 inch.

3. Non-Rotational Elements
   a. Masonry and distribution plate tolerances shall be:
      1) Plan dimensions under 30 inches: minus 0 inch, plus 3/16 inch
      2) Plan dimensions over 30 inches: minus 0 inch, plus 1/4 inch
      3) Thickness tolerance shall be: minus 1/16 inch, plus 1/16 inch
      4) Class “C” tolerance for the underside and Class “A” tolerance for the upper side in contact with other bearing components.
   b. Sole plates shall conform to:
      1) Plan dimensions under 30 inches: minus 0 inch, plus 3/16 inch
      2) Plan dimensions over 30 inches: minus 0 inch, plus 1/4 inch
      3) Center line thickness: minus 1/16 inch, plus 1/8 inch
      4) Bevel (if required): plus or minus 0.001 radian
      5) Class “B” tolerance for the upper side and Class “A” tolerance for the underside (i.e., side contacting stainless-steel sliding surface) in contact with other bearing components.
   c. Guide bar tolerance shall be:
      1) Length: plus or minus 1/8 inches
      2) Section dimensions: plus or minus 1/16 inch
      3) Flatness where it bears on another plate: Class “A”
      4) Bar-to-bar, nominal dimension: plus or minus 1/16 inch and not more than 1/16 inch out of parallel.
   d. Overall bearing height shall not vary from nominal height dimension by more than plus 1/4 inch or less than minus 1/16 inch.

2.5 PAINTING OR METALIZING

A. The bearing assemblies shall be shop painted in accordance with the paint manufacturers recommendations or zinc metalized in accordance with AWS C2.18. Galvanizing and field painting shall not be permitted. The surfaces to be painted or metalized are shown in the shop drawings. The pot cavity, piston face width, and all surfaces covered by stainless steel, bronze or PTFE sheet shall not painted or metalized.

PART 3 - EXECUTION

3.1 SAMPLING, TESTING, AND INSPECTION

A. Sampling, testing, and inspection shall be performed on a number of bearings designated by the Contractor's engineer. Tests shall be performed in the presence of a representative of an independent testing agency hired by the Contractor in accordance with Section 18.1.5 of the AASHTO LRFD Bridge Construction Specification. The number of tests, up to five separate tests shall be performed. The Contractor's engineer shall designate the number based on the type of bearings required for the project. The first three tests shall be conducted on all bearing types (fixed, guided expansion and non-guided expansion) and include a dimensional check, clearance test, and short-term compressive proof load test. The short-term compressive proof test shall consist of loading the bearing to 150 percent of the vertical design capacity at the design rotation. During the test or upon disassembly, the bearing shall show no signs of permanent deformation of the elastomer or PTFE. The fourth test shall measure the coefficient of friction on a representative sliding bearing (guided and non-guide expansion) following the provision in Section 18.1.5.2.6 of the AASHTO LRFD Bridge Construction Specification. The fifth test shall be conducted on the fixed and guided bearing assemblies to verify the horizontal load carrying capacity following the provision in Section 18.1.5.2.8 of the AASHTO LRFD Bridge Construction Specification. Long-term deterioration tests are not required for sampled bearings.

3.2 INSTALLATION

A. When placed, bearings shall be dry, clean, and free from dirt, oil, grease, or other foreign substances.

B. Bearings shall be installed in strict accordance with the manufacturer's instructions and in accordance with the alignment plan and installation scheme as shown in the Construction Drawings, as applicable.

C. Bearing devices shall not be disassembled unless otherwise permitted in writing by the Contractor's engineer or manufacturer.

D. Bearing assemblies shall be handled by their bottom surfaces only. Do not lift bearings by their tops, sides, or shipping bands.

E. Caution shall be taken to ensure that the steel temperature directly adjacent to the rotational element does not exceed 200 degrees F. The polyether urethane disc shall not be exposed to direct flame or sparks. In addition, no weld current shall pass between bearing plates on either side of the urethane disc.

3.3 FIELD QUALITY CONTROL

A. Upon final installation of the bearings, the Contractor's engineer, in the presence of the manufacturer's representative if required, shall inspect the bearing components to ensure that they are level and parallel to within plus or minus 0.005 radian. Deviations in excess of the allowed tolerance shall be corrected.

END OF SECTION

SECTION 07 95 66

BRIDGE EXPANSION JOINT ASSEMBLIES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Bridge Expansion joint assemblies.

B. Fire-rated joint cover assemblies.

1.2 RELATED SECTIONS

A. Expansion and isolation joint fillers and sealants for concrete slabs and paving are specified in Section 03 15 00, Concrete Accessories.

1.3 REFERENCE STANDARDS

A. American Association of State Highway and Transportation Officials (AASHTO):

1. AASHTO LRFD Bridge Design Specifications
2. AASHTO LRFD Bridge Construction Specifications
3. AASHTO/AWS D1.5M/D1.5 Bridge Welding Code
4. AASHTO M111 Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
5. AASHTO M164 Standard Specification for High-Strength Bolts for Structural Steel Joints
6. AASHTO M298 Standard Specification for Coating of Zinc Mechanically Deposited on Iron and Steel

B. ASTM International (ASTM):

1. ASTM A240 Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
2. ASTM A709/A709M Standard Specification for Structural Steel for Bridges
3. ASTM D395 Standard test Method for Rubber Property – Compression Set
4. ASTM D412 Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension
5. ASTM D471 Standard Test Method for Rubber Property – Effect of liquids
6. ASTM D573 Standard Test Method for Rubber – Deterioration in an Air Oven
7. ASTM D1149 Standard Test Methods for Rubber deterioration-Cracking in an Ozone Controlled Environment
8. ASTM D2000 Standard Classification System for Rubber Products in Automotive Applications
9. ASTM D2240 Standard Test Method for Rubber Property – Durometer Hardness
10. ASTM D3542 Standard Specification for Preformed Polychloroprene Elastomeric Joint Seals for Bridges

11.	ASTM E119	Standard Test Methods for Fire Tests of Building Construction & Materials
12.	ASTM E814	Standard Test Method for Fire Tests of Penetration Firestop Systems
13.	ASTM F738	Standard Specification for Stainless Steel Metric Bolts, Screws, and Studs

C. American Welding Society (AWS):

1.	AWS D1.5	Bridge Welding Code
2.	AWS QC 1	Standard for AWS Certification of Welding Inspectors

D. California Department of Transportation (Caltrans) Standard Specifications:

1.	Section 59-2	Painting Structural Steel

E. National Cooperative Highway Research Program (NCHRPP):

1.	NCHRP Report 402	Fatigue Design of Modular Bridge Expansion Joints

F. Underwriters Laboratories Inc. (UL):

1. Building Materials Directory
2. Fire Resistance Directory

G. Warnock Hersey (WH):

1. Certification and Listings Directory

1.4 SUBMITTALS

A. Product Data and Shop Drawings: Submit details of the expansion joint system to be used together with installation and waterproofing plans for Contractor’s engineer’s approval prior to fabrication of the joint assembly. Product data and drawings shall include the following:

1. Plans, elevation, and section of the joint system for each movement rating and roadway width showing dimensions and tolerances.
2. All ASTM, AASHTO, and other material designations.
3. Installation Instructions: Method of installation including sequence, setting relative to temperature, anchorage during setting and installation at curbs.
4. Details of temporary supports for shipping and handling.
5. Details for bridging over expansion joint systems and otherwise protecting expansion joint systems from construction traffic.
6. Design calculations shall include a fatigue design and a strength design (when appropriate) for all structural elements, connections and splices. All welded center-beam splices shall be shown on the shop drawings.
7. Welding procedures. Submit welding procedures as specified under Section 05 05 12, Metal Welding. The welding procedure shall identify in detail the procedures to be performed in fabricating the joint.

B. Certifications of Compliance: At the time of shop drawing submittal, submit the following certifications for review and approval by the Contractor's engineer:

1. Written certifications of the manufacturer's experience.
2. Manufacturer's certificate of compliance with the AISC Quality Certification Program – Major Steel Bridges.
3. Certification that welding inspection personnel are qualified and certified as welding inspectors under AWS QC1, Standard for Qualification and Certification of Welding Inspectors.
4. Certification by expansion joint manufacturer's installation technician.

C. Fire Rating Certification: Submit evidence that the fire-rated joint covers are listed by a nationally recognized testing laboratory such as UL or Warnock Hersey directories for fire-rated joint covers.

1.5 QUALITY ASSURANCE

A. The manufacturer shall have a minimum of three years experience in designing and fabricating modular expansion joint systems.

B. The shop drawings and calculations shall be prepared, signed, and sealed by a professional engineer registered in the State of California. The registered professional engineer shall be a full-time employee of the manufacturer.

C. All expansion joint assemblies shall be fabricated by the same AISC Certified manufacturer.

D. Welding procedures shall be in accordance with AASHTO/AWS D1.5 – Bridge Welding Code.

PART 2 - PRODUCTS

2.1 TYPES OF EXPANSION JOINT SYSTEMS

A. Elastomeric Drainage Joint shall consist of flexible elastomeric material formed into a V- or Omega-shape channel fitted between girder ends that can collect water that is draining from the deck and transport that water to a drainpipe system while protecting elements below the deck from corrosion and falling objects. The elastomeric drainage joint shall not be used for openings for openings greater than 4.0 inches.

B. Strip Seal Expansion Joint System: Strip seal joint system shall consist of a strip seal of an elastomeric gland mechanically locked between two steel edge members, which provides a watertight sealing system capable of accommodating a joint opening, in the direction of the traffic, of up to 4.0 inches maximum. This system shall not be used for joint opening greater than 4.0 inches.

C. Armored Preformed Compression System: Armored joint system shall consist of a preformed elastomeric seal installed between two steel members with steel bar retainers. The system shall be capable of accommodating a joint opening, in the direction of the traffic, of up to 4.0 inches maximum. This system shall not be used for joint opening greater than 4.0 inches.

D. Modular Expansion Joint System: Modular joint system shall consist of multiple neoprene-strip-seals mechanically held in place by steel edge and separation beams. Each separation beam shall

be supported by independent multiple support bars, which are welded to the separation beams. The multiple support bars shall be suspended over the joint opening by sliding elastomeric bearings. Modular joint system shall be comprised of five main design features: elastomeric seal, steel center beam, steel edge beam, support bars, and compression spring. The system shall be supported by longitudinal displace boxes. Modular joint system shall be capable of accommodating a joint opening, in the direction of the traffic, of up to 52.5 inches.

2.2 MATERIALS

A. Structural Steel: ASTM A709/A709M, Grade 36, 50, 50W

B. Stainless Steel: ASTM A240/A240M, Type 302 or 304

C. Preformed Elastomeric Seal: ASTM D3542

D. Polychloroprene (neoprene): ASTM D2000. The elastomeric (neoprene) gland for the strip seals in the strip seal joint systems shall meet the following requirements:

Property	Requirement	Test Method
Tensile Strength, Min., psi	2,000	ASTM D412
Elongation at break, Min.	250 percent	ASTM D412
Hardness, Durometer A	60 plus or minus 5	ASTM D2240
Ozone Resistance, 20 percent 300 pphm 70 hrs@104 degrees F Wipe surfaces with solvent to remove contamination	No cracks	ASTM D1149
Heat Aging 70 hrs@ 212 degrees F Tensile Strength, Max. decrease Elongation, Max. decrease Hardness, max. point change	 20 percent 20 percent plus 10, minus 0	ASTM D573
Oil Swell, ASTM Oil #3, 70 hrs@212 degrees F Max. weight increase	45 percent	ASTM D471
Compression set, 70 hrs@212 degrees F	40 percent max.	ASTM D395
Low Temperature Stiffening, 7 days@14 degrees F Hardness Type A Durometer, point change	0 to plus 15	ASTM D2240

E. Polytetrafluorethylene (PTFE): PTFE shall be 100 percent virgin Telfon, woven PTFE fabric or dimpled PTFE conforming to the requirements of AASHTO LRFD Construction Specifications, Section 18.8.2.

F. Expansion Joint Seals For Modular Joint System: The maximum movement range of the expansion joint strip seals shall be 3.15 inches and meeting the following requirements:

Property	Requirement	Test Method
Hardness, Durometer A	65 plus or minus 5	ASTM D2240
Tensile Strength	2,000 psi (min.)	ASTM D412
Elongation at break	250 percent (min.)	ASTM D412
Compression set, 70 hrs@212 degrees F	40 percent (max.)	ASTM D395

G. Bolts, Nuts, and Washers: Conforming to the requirements of AASHTO M164 and shall be galvanized in accordance with AASHTO M298.

H. Slide Bearing and Precompressed Springs: Bearing and springs shall be fabricated as steel reinforced elastomeric pads with a polytetraflourethylene (PTFE) sliding surface. Components manufactured from polyurethane compounds will not be allowed.

I. Other Materials: Other materials shall meet the requirement of the AASHTO LRFD Bridge Design Specifications.

2.3 DESIGN REQUIREMENTS

A. Expansion Joint Assemblies

1. Metal components in the expansion joint systems shall be structural steel conforming to ASTM A709/A709M or conforming to AASHTO LRFD Bridge Design Specifications. Aluminum components will not be allowed.
2. To the greatest extent possible, fabricate expansion joint systems as one continuous unit without field splices. If practical shipping limits, site, or construction requirements dictate the need for field splices, the splices shall be located in areas outside the main traffic lanes or tracks. Field splices shall be completed in accordance with the details and procedures included in the shop drawings.
3. Strip seal glands shall be prefabricated in the shop to fit the final dimensions of the joint as it occurs in the roadway or trackway. Field splices of the strip seal glands will not be permitted except as otherwise allowed.
4. Retainer rails (edge members) for the strip seal joint and modular joint systems shall be one-piece construction. Built-up sections by welding separate pieces together in any manner to form their final shape are not allowed.
5. The modular expansion joint systems shall be designed to accommodate all vertical design loads and all expected longitudinal movements (i.e. thermal, creep, shrinkage, elastic shortening etc.) as well as vertical and horizontal rotations. The design shall incorporate strip seal glands with a maximum movement range of 3 inches per seal.
6. In the modular expansion joint systems, the transverse separation beams, support bars, and other structural elements shall be fatigue tested and designed following the guidelines provided in NCHRP Report 402 as well as the provisions included in AASHTO LRFD Bridge Design Specifications, Section 14: Joints and Bearings.
7. In the modular expansion joint systems, the elastomeric springs and bearings shall be designed so that they are removable and replaceable. The removal and reinstallation of the strip seals shall be easily accomplished from above the joint with a minimum gap width of 1.25 inches. These operations shall be done with partial closure of the roadway.
8. The expansion joint assembly seals shall not protrude above the top of the joint.
9. The expansion joint system shall be watertight.

B. Fire-Rated Joint Cover Assemblies

1. Requirements: If fire-rated joint covers are needed, the fire-rated joint covers shall have been tested in accordance with ASTM E119 and ASTM E814, including hose stream test at full rated period. Covers shall be classified by a nationally recognized testing laboratory. Minimum fire rating shall be two hours, but not less than rating of adjacent construction. Materials shall be inorganic and shall not create smoke or contribute fuel during a fire.
   a. Metal components and cover plates shall be 300 Series (18-8) stainless steel with No. 4 finish.

2. Fire Barrier: Fabricated of layers of ceramic fiber insulation and metallic insulation.
3. Flame Sealant: Sealant shall remain resilient to permit joint movement and shall, upon exposure to heat, increase in volume to resist penetration of fire through voids in construction.
4. Fireproofing: Of type required by fire rating; asbestos is not acceptable.
5. Fire-Rated Joint Covers: Fire barrier and flame sealant shall provide required fire rating.

2.4 FABRICATION

A. The expansion joint system shall be fabricated in accordance with the dimensions, shapes, designs, and details shown in the approved shop drawings and in conformance with AASHTO LRFD Bridge Construction Specifications.

2.5 CORROSION PROTECTION

A. All steel surfaces, except where noted, shall be protected against corrosion by one of the following methods:

1. Hot-dip galvanized in accordance with AASHTO M111, Zinc Coatings on Iron and Steel Products.
2. Painting of the expansion joint devices shall be performed in accordance with Caltrans Standard Specifications Section 59-2, Painting Structural Steel. Surfaces under stainless steel or surfaces in direct contact with the seal do not require paint. Backer rod shall be placed in the rail's seal cavity if painting is required.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Expansion Joint Assemblies:

1. Follow the manufacturer's installation instructions as set forth in the shop drawings and other published literature.
2. Polyurethane backer rod shall be placed in the seal cavity of the steel retainer rails prior to pouring concrete. The backer rod shall remain in place until such time as the joint has been placed and the final concrete pour has completed.
3. The modular expansion joint system shall be installed in strict accordance with the manufacturer's instructions, and the advice of the manufacturer's installation technician. The permanently installed expansion joint system shall match the finished roadway or trackway profile and grades.

4. The modular expansion joint system shall be set to the proper width for ambient temperature at the time of setting.
5. Exercise care and protect the expansion joint system from damage. Prior to installation of the expansion joint assembly, protect the blockout and supporting system from damage and construction traffic. After installation of the joint system, allow no construction loads on the expansion joint device. Bridge over the expansion joint assembly in the manner indicated on the shop drawings.
6. Remove forms and debris that tend to interfere with the free movement of the expansion joint system.

B. Fire-Rated Joint Assemblies

1. Install as required to meet fire-rated design and construction. Install fire barriers and flame sealant as required to complete the installation and meet fire-rating requirements.

3.2 FIELD QUALITY CONTROL

A. Obtain written certification, signed and dated by the expansion joint manufacturer’s installation technician, that proper installation procedures were followed.

B. After the expansion joint system has been completely installed, flood with water for a minimum of 1 hour to a minimum depth of 3 inches. If leakage is observed, repair expansion joint system. The repair procedure shall be as recommended by the manufacturer and accepted by the Contractor’s engineer.

C. For the modular joint assemblies, provide the services of a qualified installation technician who is employed full-time by the manufacturer of the expansion joint system to be installed in this project. Recommendations made by the expansion joint manufacturer’s installation technician, on or off the job site, and accepted by the Contractor’s engineer, shall be followed. The expansion joint manufacturer’s installation technician shall advise the Contractor and certify that the proper installation procedures have been followed.

END OF SECTION

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SECTION 07 95 73

TUNNEL SEISMIC JOINT ASSEMBLIES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Seismic Expansion Joint Seals.

1.2 RELATED SECTIONS

A. Waterstops are specified in Section 03 15 13, Waterstops.

B. Anchor bolts and galvanizing of steel and ferrous metal items for concrete embedment are specified in Section 05 50 00, Metal Fabrications.

1.3 REFERENCE STANDARDS

A. ASTM International (ASTM):

1.	ASTM A36	Standard Specification for Carbon Structural Steel
2.	ASTM A240	Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
3.	ASTM C509	Standard Specification for Elastomeric Cellular Preformed Gasket and Sealing Material
4.	ASTM C864	Standard Specification for Dense Elastomeric Compression Seal Gaskets, Setting Blocks, and Spacers
5.	ASTM F738	Standard Specification for Stainless Steel Metric Bolts, Screws, and Studs

B. Underwriters Laboratories Inc. (UL):

1. Building Materials Directory

1.4 SUBMITTALS

A. Product Data and Shop Drawings: Submit manufacturers' product data of seismic expansion joint closures, assemblies, seals, and sealants for review and approval. Include installation details.

1. Include drawings of the rubber joint seals and the clamping system as shown on the Construction Drawings for review and approval.

B. Calculations: Submit calculations showing that the safety against water ingress is sufficient during the design life of 100 years. The calculations shall include the relaxation of the rubber material during the subway box design life and all the expected movements.

C. Installation Instructions: Submit detailed installation instructions for the rubber joint seals.

1.5 WARRANTY

A. Warranty for effective performance of joint seal materials shall be for 10 years without earthquake.

PART 2 - PRODUCTS

2.1 SEISMIC EXPANSION JOINT SEALS

A. The rubber joint seals are the primary permanent watertightness seal between the tunnel lining and structure elements. The seals shall have a 100-year design life without replacement or maintenance and shall be able to resist movement caused by differences in temperature, shrinkage, creep, and seismic action.

B. Watertightness

1. Safety factor for strength capacity of the rubber joint seal shall be a minimum of 2.5, with the design movements and the aging effect of the rubber material taken into account.
2. The clamping system shall result in a contact pressure minimum of 2.5 times the external water pressure, with the relaxation of the rubber material taken into account.

C. Seismic expansion joint seals shall be styrene butadiene rubber (SBR) seals and reinforced with layers of nylon plies of type and size to suit the construction as indicated. Rubber and nylon elements of the seal shall be in accordance with the material properties as shown in the following tables:

1. Rubber:

Property	Value	Unit	Test Method
Type of polymer	SBR		NEN-ISO 1629
Specific gravity Hardness Tensile strength Elongation at break	1160 ± 30 65 ± 5 min. 17 min. 450	[kg/m3] [Shore A] [MPa] [%]	ISO 2781 ISO 7619 ISO 37 (type 2) ISO 37 (type 2)
Compression set (72 hours at 23 degrees C)	max. 20	[%]	ISO 815B
Aging in hot air (168 hours, 70 degrees C) Change of: hardness tensile strength - elongation at break	 max. ± 6 max. -15 max. -25	 [Shore A] [%] [%]	 ISO 188 ISO 7619 ISO 37 (type 2) ISO 37 (type 2)
Stress relaxation at 25 percent compression	max. 6	[%/dec.]	ISO 3384A
Water absorption (6 hours at 100 degrees C)	max. 20	[g/m2]	NEN 5609

Property	Value	Unit	Test Method
Precision statement: • All tests are performed according to international standards. • Note that these test methods have a limited accuracy, which is often described in a precision statement as an Annex of the corresponding standard. • If some test results are not within the required limits, they can be considered as "acceptable" if the values of these test results are within the limits, with respect to the accuracy boundaries of the appropriate test method.			

2. Nylon:

Required Properties		Unit	Std.	Min.	Max.	Remarks
Width		mm	1410	1385	1435	EN 1773
Mass per unit area		g/m²	1120	1000	1240	EN 12127
Thickness		mm	1.10	0.99	1.21	ISO 5084 (2130-28)
Base fabric thickness		mm	0.60			
Warp count		epd	85x2	80x2	90x2	EN 1049-2
Weft count		ppd	85	80	90	EN 1049-2
Breaking strength	warp	N/mm	105	105	open	ISO 5081 treated-coated
	weft	N/mm	105	105	open	ISO 5081 treated-coated
EABL,	warp	%	43	-	-	ISO 5081 treated-coated
	weft	%	48	-	-	ISO 5081 treated-coated
HAS; "free" 150°C	warp	%				2130-05
	weft	%				2130-05
Peel adh; RT	warp	N/mm	7.0	7.0	open	ISO 36 (2130-01)
Length of rolls		m	order			

D. Materials and requirements include the following:

1. Visual Seals: Dense neoprene or dense silicone synthetic rubber conforming to ASTM C864, of 70 durometer hardness, plus or minus 5.
2. Functional Seal: Closed cell neoprene synthetic rubber conforming to ASTM C509, medium density.
3. Corner Angles: Stainless steel conforming to ASTM A240 and ASTM A480, Type 304 or 316.
4. Fasteners: Stainless steel conforming to ASTM F738 or equivalent, Type 316 or equivalent 300 Series (18-8) stainless steel.
5. Sealant: Sealant for installation behind steel retainer, in rear pocket of steel retainer, and at joints, where indicated, shall conform to ASTM C834, C920, or C1085 as appropriate for the construction and exposure conditions.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Seismic Expansion Joint Seals: Install seismic expansion joint seals as indicated and in accordance with the approved shop drawings and the manufacturer's installation instructions and recommendations.

1. Furnish the services of the rubber joint seal manufacturer’s technical representative to advise the Contractor during the installation of the rubber joint seals.

B. Construction

1. The rubber joint seal shall be clamped to the element end frames. The bolts shall be tensioned to a force in accordance with the manufacturer’s specifications. The corresponding tension torque shall be determined by the manufacturer’s technical representative. After 1 week, all bolts shall be re-tensioned. All connections shall be watertight.
2. The closing joint manufacture shall be done near the invert. To make the closure joint vulcanization possible, the last several feet of the rubber joint seal do not have to be installed. The part near the middle shall be loose for approximately 6 feet.

3.2 FIELD QUALITY CONTROL - INSPECTION AND SITE TESTING

A. After the bolts have been tensioned and re-tensioned, the seal shall be tested for watertightness.

B. By means of cast-in pipes, a water pressure in the space between primary and secondary seal corresponding to the mean water depth plus 33 feet shall be applied. After 24 hours the water pressure shall be a minimum 90 percent of the initial pressure

END OF SECTION

SECTION 09 96 00

HIGH-PERFORMANCE COATINGS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. High-performance coatings for steel.

B. Exterior and interior, steel fabricator shop and field applied,

1.2 RELATED SECTIONS

A. Surface preparation, priming, and finish coats specified in this Section are in addition to shop priming and surface treatment specified under other Sections.

1.3 REFERENCE STANDARDS

A. ASTM International (ASTM):

1. ASTM D16 Standard Terminology for Paint, Related Coatings, Materials, and Applications
2. ASTM D4417 Standard Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel
3. ASTM E337 Standard Test Method for Measuring Humidity with a Psychrometer (the Measurement of Wet- and Dry-Bulb Temperatures)

B. NACE International (Formerly known as National Association of Corrosion Engineers):

1. NACE Certified Inspector Program

C. The Society for Protective Coatings (SSPC):

1. SSPC-PA 2 Procedure for Determining Conformance to Dry Coating Thickness Requirements
2. SSPC-QP 1 Standard Procedure for Evaluating the Qualifications of Industrial/Marine Painting Contractors (Field Application to Complex Industrial and Marine Steel Structures)
3. SSPC-QP 3 Certification Standard for Shop Application of Complex Protective Coating Systems
4. SSPC-SP 1 Solvent Cleaning
5. SSPC-SP 6/NACE No. 3 Commercial Blast Cleaning
6. SSPC-SP 11 Power Tool Cleaning to Bare Metal
7. SSPC - Steel Structures Painting Manual, Volumes 1 and 2
8. SPPC VIS 1 Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning

1.4 DEFINITIONS

A. Interior: Defined as surfaces that are within heated and air conditioned spaces, areas and rooms. Ceiling cavities and plenums above conditioned spaces and within the confines of the exterior walls shall be considered as interior.

B. Exterior: Defined as surfaces that are exposed to temperature and humidity variations, precipitation, and ultraviolet light. Exterior shall include spaces and areas that are covered by roof structures but are not heated and air conditioned.

C. Coatings Terminology: Refer to ASTM D16 for definitions of terms related to coating work not otherwise defined in this Section.

1.5 PRE-APPLICATION MEETINGS

A. Pre-Application Meeting: Convene a pre-application meeting three weeks before start of application of coating systems. Require attendance of parties directly affecting work of this Section, including Contractor, Contractor’s structural engineer or architect, Contractor’s inspector, Independent Coating Inspector, applicator, and manufacturer’s representative. Review the following:

1. Environmental requirements.
2. Protection of surfaces not scheduled to be coated.
3. Surface preparation.
4. Application.
5. Repair.
6. Field quality control.
7. Cleaning.
8. Protection of coating systems.
9. One-year inspection.
10. Coordination with other work.

1.6 SUBMITTALS

A. Product Data: Submit for each coating system.

1. Material List: Inclusive list of required coating materials identifying each by manufacturer's product number and general classification.
2. Manufacturer's Information: Technical information, including label analysis and instructions for handling, storing, and applying each coating material. Include instructions for preparation for and field touch up of primer and finish coats.
3. Manufacturers Certification: Stating that products supplied will comply with local regulations controlling use of volatile organic compounds (VOC).

B. Detailed Coating Schedule: Submit schedule detailing type of surface, specific data for each coating material, and number of coats required.

C. Samples for Verification Purposes: Submit for each substrate, separate coat, coating color and material to be applied, with texture to simulate actual conditions, on 8 inch by 10 inch stepped samples of the actual substrate to be coated. Use representative colors when preparing samples for review. Label each sample with product data defining each separate coat, including primers. Resubmit until required sheen, color, and texture are achieved.

D. Manufacturers Project Acceptance Document: Submit certification and acceptance of compatibility and suitability of materials scheduled with substrate and project conditions indicated.

E. Maintenance Instructions: Submit manufacturers' instructions for maintenance of installed work, including methods and frequency for maintaining optimum condition under anticipated use. Include precautions against cleaning materials and methods which may be detrimental to finishes and performance.

F. Applicator's Qualification: Submit applicator's resume, include list of a minimum of 5 completed projects of similar size and complexity to this Work. Include for each project:

1. Project name and location.
2. Name of owner.
3. Name of contractor.
4. Name of engineer or architect.
5. Name of coating manufacturer.
6. Approximate area of coatings applied.
7. Date of completion.

G. Manufacturer's Technical Representative's Qualifications: Submit resume.

H. Independent Coating Inspector's Qualifications: Submit resume.

I. Contractor's Field Quality Control: Submit specified reports. Include completed Surface Preparation and Coating Inspection Record.

J. Independent Coating Inspector's Reports: Submit reports. Submit Surface Preparation and Coating Inspection Record daily with a copy to the Contracting Officer.

K. Manufacturer Technical Representative's Reports: Submit reports of representative's periodic inspections.

L. The Independent Coating Inspector shall propose for the Contracting Officer's acceptance a breakdown into areas (portions) for each coating system for the purposes of requiring a separate Surface Preparation and Coating Inspection Record for each area. The Contractor shall utilize the same breakdown in its Field Quality Control.

1.7 QUALITY ASSURANCE

A. Material Requirements:

1. Compatibility: Provide materials that are compatible with one another under conditions of service and application required, as demonstrated by manufacturer based on testing and field experience.
2. Single Source Responsibility: Provide primers and undercoat material produced by the same manufacturer as the finish coats for each type of coating. Use only thinners recommended by the manufacturer and only within recommended limits.

B. Applicator Qualifications: Applicator shall be experienced in performing high-performance coating work, shall have completed not less than 10 years with coating system applications

similar in material and extent to those indicated for Project, and have a record of successful in-service performance.

1. Applicator shall be certified by SSPC-QP 1 for surface preparation and field coating application and SSPC-QP 3 for shop painting, as applicable.
2. Applicator's Personnel: Persons trained for application of specified coatings.

C. Manufacturer's Technical Representative Qualifications: Direct employee of technical services department of manufacturer with minimum of 5 years experience in providing recommendations, observations, evaluations, and problem diagnostics. Sales representatives are not acceptable.

D. Independent (third party) coating inspector shall be certified under NACE Certified Inspector Program as a Level 3 Certified Coating Inspector. Also Coating Inspector shall have documented experience in the inspection of the system of type specified for projects of similar size and character.

E. Quality Standard for Steel Preparation: Surface preparation and painting practices shall conform to the SSPC - Steel Structures Painting Manual, Volumes 1 and 2.

F. Regulatory Requirements: Comply with Federal, State and local requirements for allowable volatile organic compounds (VOC).

G. Field Applied Mock-Ups: Provide a full-coat finish mock-up of each type of coating and substrate required on the Project. Mock-ups may be actual substrates of the Work. Duplicate finish of approved prepared samples.

1. Select one surface, approved by the Contractor's architect or engineer, to represent surfaces and conditions for each type of coating and substrate to be painted.
2. Apply coatings to each surface according to the Schedule or as specified. Provide required sheen, color, and texture on each surface.
3. After finishes are accepted, the surface shall be used to evaluate coating systems of a similar nature.

1.8 DELIVERY, STORAGE, AND PROTECTION

A. Delivery: Deliver coating materials to the job site in manufacturer's original, new, unopened packages and containers bearing manufacturer's name and label and following information:

1. Name or title of material.
2. Manufacturer's name, stock number, and date of manufacture.
3. Contents by volume.
4. Thinning instructions (if permitted).
5. Application instructions.
6. Color name and number.
7. Handling instructions and precautions.

B. Storage: Store materials not in actual use in accordance with weather, temperature, humidity and substrate conditions recommended by material manufacturer, in tightly covered containers at a minimum ambient temperature of 45 deg F in a well-ventilated area. Maintain containers used in storage of coatings in clean condition, free of foreign materials and residue.

C. Protection: Protect work of other trades and vehicles, structures, landscaping, paving, and other surfaces on and off the site from marking or injury from coating application and from field surface preparation.

1.9 PROJECT CONDITIONS

A. Weather Condition Limitation:

1. Proceed with coating work only when existing and forecasted weather conditions will permit application of coating material in accordance with manufacturers' recommendations and warranty requirements.
2. Work may continue during inclement weather if surfaces and areas to be coated are enclosed and heated within temperature and humidity limits specified by manufacturer during application and drying periods and job site conditions are acceptable to the manufacturer and applicator.
3. If anticipated time of coating application is such that weather would likely restrict coating application, the Contractor may, with the written acceptance of the Contractor’s architect or engineer, apply complete finish system within shop.

1.10 MAINTENANCE MATERIALS

A. Field Touch-Up Kits: Furnish to the Authority field touch-up kits complete with preparation, mixing, and application instructions for each coat and color used. Kits shall consist of quart containers. Larger containers may be acceptable if accepted by the Contracting Officer. Quantity of kits shall equal one gallon for each 5,000 square feet of coating.

PART 2 - PRODUCTS

2.1 PRODUCTS

A. Coating system shall be high performance coating system approved by the Contractor’s architect or engineer such as polysiloxane, polyaspartic modified urethane, or fluoropolymer which may be applied in the field. Primer shall be inorganic or organic zinc as recommended by the manufacturer of finish coats. Coatings including primers shall comply, at minimum, with South Coast Air Quality Management District (SCAQMD) Rule 1113.

B. Material Compatibility: Provide primers, intermediate coat materials, finish coat materials, and related materials that are compatible with one another and the substrates indicated under conditions of service and application as demonstrated by the manufacturer based on testing and field experience.

C. Colors: As indicated in the Construction Drawings or other Contractor provided documentation.

2.2 SHOP QUALITY CONTROL

A. The requirements specified herein in the Article entitled “Field Quality Control” apply to surface preparation and shop application of prime coat and, if applicable, other shop coats.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrate surfaces to receive high performance coatings for steel and associated work and conditions under which work will be installed. Correct unsatisfactory conditions prior to proceeding with coatings work. Starting of work within a particular area will be construed as installers' acceptance of surface conditions.

3.2 PREPARATION

A. Coordination of Work: Review other Sections in which shop applied primers are provided to ensure compatibility of the total system for various substrates. Coordinate with shop applicators and ensure use of compatible primers.

B. General: Remove plates, machined surfaces, and similar items already in place that are not to be coated, or provide surface-applied protection prior to surface preparation and coating. Remove these items, if necessary, to completely coat the items and adjacent surfaces. Following the coating operations in each space or area, have removed items reinstalled by workers skilled in the trades involved. After completing coating operations, reinstall items that were removed.

   1. Areas which may become inaccessible or difficult to coat after erection shall be coated prior to assembly or erection.

C. Cleaning: Before applying coatings or other surface treatments, clean the substrates of substances that could impair bond of the various coatings. Remove oil and grease prior to cleaning. Schedule cleaning and coating application so dust and other contaminates from the cleaning process will not fall on wet, newly coated surfaces.

   1. Marks for color coding of bulk materials and erection marking which are not compatible with coating system shall be removed or sealed as instructed in the coating system manufacturer's instructions.

D. Ferrous Metals Surface Preparation: Clean and prepare surfaces to be coated according to the manufacturer's instructions for each particular substrate condition as scheduled in either the fabricator's shop or in field.

E. Ferrous Metals Surface Preparation: Uncoated Metal Surfaces:

   1. Fabrication Defects: Correct steel and fabrication defects revealed by surface preparation.
      a. Scrape or grind protrusions flush with surface.
      b. Remove weld spatter and slag.
      c. Round sharp edges and corners of welds to a smooth contour.
      d. Smooth weld undercuts and recesses.
      e. Grind down porous welds to pinhole-free metal.
      f. Remove weld flux from surface.

   2. Remove oil, grease, dirt, loose mill scale and other foreign substances using methods that comply with SSPC/NACE recommendations.
   3. Blast-clean steel surfaces as recommended by the coating system manufacturer and according to the requirements of SSPC/NACE Specification referenced herein.
      a. Achieve surface profile recommended by the primer manufacturer.

b. Coat abrasive blast-cleaned surfaces with primer before visible rust forms on surface. Do not leave blast-cleaned surfaces uncoated for more than 8 hours.

4. Ensure surfaces are dry.
5. Treat cleaned metal with a metal treatment wash coat prior to priming.

F. Ferrous Metals Surface Preparation: Coated Metal Surfaces: Remove foreign substances using methods that comply with coating system manufacturer recommendations. Touch-up bare areas and previous coatings that have been damaged.

G. Material Preparation: Carefully mix and prepare coating materials according to the manufacturer's directions.

1. Maintain containers used in mixing and application of coatings according to the manufacturer's directions.
2. Stir materials before applying to produce a mixture of uniform density; stir as required during application. Do not stir surface film into the material. Remove film and, if necessary, strain the coating material before using.
3. Use only the type of thinners approved by the manufacturer and only within recommended limits.

H. Tinting:

1. Tinting at the site is not permitted.
2. Tint undercoats to match color of finish coat, but provide sufficient difference in shade to distinguish each separate coat.

3.3 APPLICATION

A. General: Apply high performance coatings according to manufacturer's instructions, approved submittals, and Contract Documents.

B. Application Requirements:

1. Use application techniques best suited for the coating materials being applied. Apply shop coatings by brush, roller, spray, or other applicators according to coating manufacturer's instructions. Apply field coatings by brush or roller according to coating manufacturer's instructions, no spray application of field coatings.
   a. Brush Application: Use brushes best suited for material applied and of appropriate size for surface or item being coated. Brush out and work brush coats into surfaces in an even film.
   b. Roller Application: Use rollers of carpet, velvet back, or high-pile sheep's wool as recommended for material applied.
   c. Spray Application:
      1) Spray application may only be used for shop application.
      2) Use mechanical methods to apply coatings if permitted by manufacturer and governing regulations. Use spray equipment with orifice size as recommended by manufacturer for material being applied. Do not double back with spray equipment building up film thickness of 2 coats in one pass, unless recommended by manufacturer.

2. The number of coats and film thickness required is the same regardless of the application method. Do not apply succeeding coats until the previous coat has cured as recommended by the manufacturer. Where sanding is required, according to the manufacturer's directions, sand between applications to produce a smooth, even surface.
3. Apply coating systems to provide an opaque, smooth surface of uniform finish, color, appearance, and coverage. Cloudiness, spotting, holidays, laps, brush marks, runs, sags, ropiness, or other surface imperfections shall not be accepted.
4. Make edges of coatings adjoining other materials clean and sharp with no overlapping. Work material into surfaces voids and hairline cracks.
5. Do not apply coatings over dirt, rust, scale, grease, moisture, scuffed surfaces, or conditions detrimental to forming a durable coating film.
6. Do not use materials that are beyond the manufacturers recommended pot life.
7. Do not apply initial coating until moisture content of surface is within limitations recommended by coating manufacturer according to moisture meter testing.
8. Do not apply succeeding coats until previous coat has cured as recommended by coating manufacturer. Do not exceed manufacturer's recommended maximum time limit for re-coating. If the manufacturer's recommended maximum time limit has been exceeded, prepare surface as required by manufacturer prior to applying next coat.

C. Primer Application: Apply primer coats to surfaces, in fabricator's shop or in field as indicated in schedules below, that have been cleaned, pretreated (if required), or otherwise prepared for coating as soon as practical after preparation and before subsequent surface deterioration.

D. Finish Coats:

1. Recoat primed surfaces where there is evidence of suction spots or unsealed areas in first coat, to assure a finish coat with no burn-through or other defects due to insufficient sealing.
2. When undercoats or other conditions show through the final coat, apply additional coats until the cured film has a uniform coating finish, color, and appearance. Give special attention to edges, corners, crevices, welds, exposed fasteners, and similar surfaces to ensure that they receive a dry film thickness equivalent to that of flat surfaces.

E. Completed Work: Match approved samples for color, texture, and coverage. Remove, refinish, or recoat work that does not comply with specified requirements.

3.4 REPAIR

A. Repair defects such as overspray, runs, sags, voids, blistering, peeling, rusting, inadequate cure, and lack of adhesion according to the touch-up and repair procedures accepted by the Authority.

B. Remove mud cracking on steel, except sheet metal by blasting. Remove mud cracking on sheet metal per SSPC-SP 11; take care to avoid deformation of the metal. Suitably restore the surface profile for the specified paint material.

3.5 FIELD QUALITY CONTROL

A. Contractor's Field Quality Control: Field Quality Control tests and inspection outlined herein shall be augmented under the Contractor's Quality Management System as required, for example, to protect structures in accordance with the CHSTP Design Criteria. Verify that the following are as specified and document verification. .

1. Coatings and other materials.
2. Surface preparation and application.
3. Environmental conditions prerequisite for each coat.
4. Surface conditions prerequisite for each coat.
5. Minimum and maximum re-coating time limitations and pot life expiration times.
6. Mixing, thinning, and induction time.
7. DFT of each coat and total DFT of coating system using wet film and dry film gauges.
8. Coating Defects: Check coatings for film characteristics or defects that would adversely affect performance or appearance of coating systems.
9. Report:
   a. Complete Surface Preparation and Coating Inspection Record for each portion of the work for each system. The breakdown of portions of the work shall be as agreed to by the Contracting Officer. Records shall be in addition to those of the Independent Coating Inspector.
   b. Written reports describing inspections made and actions taken to correct nonconforming work.
   c. Nonconforming work not corrected.

B. Independent Coating Inspector:

1. The Contractor shall provide an Independent Coating Inspector to perform the tests and inspections listed in this Article entitled “Field Quality Control” and additional tests and inspections as necessary to complete the Surface Preparation and Coating Inspection Record. The Independent Coating Inspector’s work shall be in addition to the Contractor’s quality control under the Contractor’s Quality Management System.
2. The Independent Coating Inspector shall complete Surface Preparation and Coating Inspection Record daily for each portion of the work for each system. The breakdown of portions of the work shall be as agreed to by the Contracting Officer. Refer to the Surface Preparation and Coating Inspection Record form at the end of the Section.
3. The Inspector shall initiate and the Contractor shall hold a meeting when, in the Inspector’s judgment, nonconforming work is not being corrected or if measures are not being made in a timely manner to prevent further non-conforming work. Meeting attendees shall be the same as those listed for the Pre-application Meeting.

C. Determination of Dry Film Thickness (DFT):

1. Dry film thickness of each coat shall be according to the requirements specified herein or manufacturer’s recommendation, whichever is greater.
2. The required DFT shall be a minimum of the profile depth of the coating, when dry, as measured from the face of the surface to be coated. The specified DFT over blasted or otherwise roughened surface requires a dry film thickness gage reading on the bare surface prior to painting. The bare surface gage reading shall then be deducted from the coated surface gage readings
3. Measure film thickness as follows:
   a. Magnetic surfaces by use of a Mikrotest or Elcometer thickness gauge in accordance with SSPC-PA 2.
   b. Nonmagnetic surfaces by wet film thickness readings, thus verifying the calculated wet film thickness required to achieve the specified dry film thickness.
   c. Disputed thickness shall have a final check using the Tooke gage.

D. Surface Preparation and Coating Inspection:

1. Determine dew point and relative humidity following procedures of ASTM E337.
2. Readings are required prior to application and approximately every four hours or at other time intervals approved in writing by the Contractor’s architect or engineer and which are acceptable to the Independent Coating Inspector. Alternatively, continuous monitoring shall be performed using systems established or approved by the Contractor’s architect or engineer in writing and which are acceptable to the Independent Coating Inspector.
3. Review temperature, humidity, and dew point readings upon noticeable deterioration of conditions or as requested by the Contracting Officer.
4. Compare blast cleaned surfaces with SSPC Vis 1, visual standards. Verify the anchor pattern profile depth in accordance with ASTM D4417.
5. Use grease-free chalk to mark local areas which do not meet specified standards.
6. Take surface temperature and humidity reading prior to application of each coat. The work shall not proceed if the ambient temperature parameters are outside the specified requirements. If more stringent, the coating manufacturer’s requirements shall dictate.
7. Visually inspect the coating for defects such as overspray, runs, sags, voids, blistering, peeling, rusting, mud cracking, inadequate cure, and lack of adhesion.

E. Manufacturer’s Field Service:

1. The Contractor shall provide the services of a manufacturer’s qualified technical representative who shall attend the Pre-application Meeting and be available to answer technical questions
2. In addition, the representative shall periodically inspect material and application to ensure installation is proceeding in accordance with manufacturer’s designs, recommendations and warranty requirements. The periodic inspections shall consist of a minimum of 2 hours every two weeks during high performance coating application for steel work, including work in fabricator's shop and work in field.
3. Representative shall submit reports of its inspections.

F. The Contractor shall furnish the necessary testing and inspection instruments, calibrated and maintained. Such equipment shall be available for use by the Contracting Officer upon request.

3.6 CLEANING

A. After completing painting, clean glass and paint-spattered surfaces. Remove spattered paint by washing and scraping.

3.7 PROTECTION AND TOUCH UP

A. Protect surfaces, structures, landscaping, and vehicles including those of adjacent property owners from damage by painting including over spray.

B. Protect work of other trades, whether being painted or not, against damage by painting. Correct damage by cleaning, repainting, repairing or replacing. Coordinate corrections with other trades involved.

C. Provide "Wet Paint" signs to help protect newly painted finishes. Remove temporary protective wrappings provided by others to protect their work after completing painting operations.

D. At completion of construction activities of other trades, touch up and restore damaged or defaced painted surfaces. Prepare areas requiring touch up as required by coating manufacturer. Touch up with materials used in the work. In the case of shop primer, primer shall be product recommended in writing by coating manufacturer for field touch up.

3.8 COATINGS FOR STEEL (HIGH PERFORMANCE COATINGS) SCHEDULE

A. Interior Surfaces of Steel Structures: At minimum, interior surfaces of steel structures such as concealed portions of box girders and tube sections shall be primed.

B. Paint and Coatings System No. 1:

1. Locations: Exterior architectural exposed structural steel (AESS) and steel bridges
2. Steel Surface Preparation: As recommended by coating manufacturer, but not less than SSPC-SP 6/NACE No. 3
3. Coatings: To be completed in the Construction Specifications.
   a. 1st Coat:
   b. 2nd Coat:
   c. 3rd Coat:

C. Paint and Coatings System No. 2:

1. Locations: Exterior: To be edited in the Construction Specifications.
   a. Miscellaneous metal fabrications.
   b. Metal stairs
   c. Pipe and tube railings.
   d. Non-galvanized sheet metal.

2. Steel Surface Preparation: As recommended by coating manufacturer, but not less than SSPC-SP 6/NACE No. 3
3. Coatings: To be completed in the Construction Specifications.
   a. 1st Coat:
   b. 2nd Coat:
   c. 3rd Coat:

END OF SECTION

SURFACE PREPARATION AND COATING INSPECTION RECORD

Page __ of

REPORT NO: ______________________________ DATE: __

PROJECT: ______________________________ DAY: M TU W TH F SA SU

SUBCONTRACTOR: ______________________________ SHIFT: __

EQUIPMENT/AREA: ______________________________ QC INSPECTOR: ______________________________

SUBSTRATE: STEEL / CONCRETE / OTHER - ______________ COATING SPEC NO/REV: ______________________

ENVIRONMENTAL CONDITIONS:

COATING WORK ACTIVITY							
TIME							
DRY BULB TEMP. ºF							
WET BULB TEMP. ºF							
RELATIVE HUMIDITY, %							
DEW POINT ºF							
SURFACE TEMP. ºF							
BLOTTER TEST							

PRE-SURFACE PREPARATION

SSPC-SP1: ______________________________ MASKING/PROTECTION: ______________________________

SURFACE DEFECTS: ______________________________

SURFACE PREPARATION

METHOD: ______________________________ ABRASIVE TYPE/SIZE/STORAGE: ______________________

CLEANLINESS SPEC: ______________ ACTUAL: ______________ PROFILE SPEC: ______________ ACTUAL: _______

EQUIPMENT: ______________________________

COATING MATERIALS & MIXING

PRODUCT(S) ______________________________ BATCH NO(S)/QUANTITIES/EXPIRATION DATE: ___________

STORAGE: ______________________________ THINNERS/BATCH NO(S)/THINNING RATIO: ______________

MIXING: ______________________________ INDUCTION TIME: ______________________________

MATERIAL TEMPERATURE: ______________________ POT LIFE EXPIRATION TIME: ______________________

COATING/LINING APPLICATION START TIME: ___________ COATING/LINING APPLICATION FINISH TIME: ____________

COAT: PRIMER/PRIMER TOUCH-UP (T.U.) / SECOND/SECOND T.U. / THIRD/THIRD T.U. / OTHER

METHOD: ________________ WFT: ____________ RECOAT TIME/TEMP: ______________ CURE TIME/TEMP: ______

EQUIPMENT: ______________________________

APPLIED COATING

DRY FILM THICKNESS: SPEC: ______________________ ACTUAL: ________________ METHOD: __________

HOLIDAY TEST: ___________ METHOD: ________________ OTHER TESTING: _________ METHOD: __

VISUAL COATING INSPECTION (FILM IMPERFECTIONS): ______________________________

TOUCH-UP AND REPAIR: ______________________________ FINAL CURE: ______________________________

COMMENTS: (Use reverse side or separate sheet if necessary) ______________________________

____

INSPECTOR'S SIGNATURE: ______________________________ DATE: _____

END OF ATTACHMENT

SECTION 31 05 00

COMMON WORK RESULTS FOR EARTHWORK

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Staking and grades.

B. Existing utilities.

C. Earthwork general requirements.

D. Subsurface extraction.

E. Rough grading and filling.

F. Excavation.

G. Embankment construction.

H. Subgrade preparation.

I. Foundation preparation.

J. Subgrade filling/raising grade.

K. Compaction.

L. Backfilling.

M. Finish grading.

N. Field quality control.

1.2 RELATED SECTIONS

A. Excavating and backfilling for subsurface drainage and utilities are specified in Section 33 05 28, Trenching and Backfilling for Utilities.

B. Aggregate drainage fill is specified in Section 31 23 26, Aggregate Drainage Layer.

C. Aggregate base course is specified in Section 32 11 23, Aggregate Base Courses.

1.3 DEFINITIONS

A. Earthwork Terminology: Terms used in this Section and not defined herein shall be interpreted in accordance with the definitions given in ASTM D653.

B. Backfill: Soil or soil-rock material used to backfill excavations and to backfill excavated spaces around foundation walls, building walls, retaining walls, head walls, and abutments.

C. Borrow: Soil or soil-rock material used for fill, backfill, embankment, or other construction that is excavated from an off-site location and hauled in.

D. Embankment: Soil or soil-rock material for embankment construction. Embankment construction includes constructing embankments and dikes, including the preparation of the areas upon which they are to be placed; and the construction of temporary surcharge embankment above the grading plane.

E. Fill: Soil or soil-rock material placed to raise the subgrade or natural grade of the site.

F. Inorganic Soil: Soil containing less than two percent by weight of organic material when tested in accordance with ASTM D2974.

G. Optimum Moisture Content: The water content at which a soil can be compacted to a maximum dry unit weight by a given compactive effort.

H. Relative Compaction: The ratio, expressed as a percentage, of the in-place dry density of material as compacted in the field to the maximum dry density of the same material as determined by laboratory test ASTM D1557.

I. Relative Density: Mass per unit volume as specified in ASTM D4253 and ASTM D4254, as applicable to the soil and test method employed.

J. Soil Classification: Soil classification is based on the Unified Soil Classification system given in ASTM D2487. Group symbols, when used, conform with the symbols of ASTM D2487.

K. Soil Group Classification: Soil group classification is based on AASHTO, and refers to the suitability of soils for re-use within the body of CHSTP track embankments. AASHTO group classification is defined and summarized in ASTM D3282. The Unified Soil Classification System and AASHTO Soil Group Classification are two separate ways of identifying soil types based on grain size and Atterberg limits.

L. Unsuitable Material: Excavated material or material below the natural ground surface in embankment areas or below subgrade elevation in excavated areas, which is unsuitable for its planned use. Note: The presence of excessive moisture in a material is not, by itself, sufficient cause for determining that the material is unsuitable. The existence of unsuitable material may be indicated in the Contract Documents or may be determined by the Contractor's geotechnical engineer during the progress of the Work. Unsuitable material is further defined as material determined to be:

1. Of such unstable nature as to be incapable of being compacted to specified density using ordinary methods at optimum moisture content; or
2. Too wet to be properly compacted and circumstances prevent suitable drying prior to incorporation into the Work; or
3. Otherwise unsuitable for the planned use.

1.4 REFERENCE STANDARDS

A. ASTM International (ASTM):

1. ASTM C131 Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine

2.	ASTM C136	Test Method for Sieve Analysis of Fine and Coarse Aggregates
3.	ASTM C535	Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
4.	ASTM D422	Method for Particle-Size Analysis of Soils
5.	ASTN D653	Terminology Related to Soil, Rocks, and Contained Fluids
6.	ASTM D1140	Test Method for Amount of Material in Soils Finer Than the 200 (75-um) Sieve
7.	ASTM D1557	Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 (2,700 kN-m/m3))
8.	ASTM D1883	Standard Test Method for CBR (California Bearing Ratio) of Laboratory-Compacted Soils
9.	ASTM D2216	Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.
10.	ASTM D2487	Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil classification System)
11.	ASTM D2974	Test Method for Moisture, Ash, and Organic Matter of Peat and Other Organic Materials
12.	ASTM D3282	Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes
13.	ASTM D4253	Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table
14.	ASTM D4254	Test Methods for Minimum Index Density of Soils and Unit Weight and Calculation of Relative Density
15.	ASTM D4318	Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
16.	ASTM D4429	Test Method for CBR (California Bearing Ratio) of Soils in Place
17.	ASTM D6938	Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

B. State of California, Department of Transportation (Caltrans), Standard Test Methods:

1. Calif. Test 217 — Method of Test for Sand Equivalent.

C. California Code of Regulations (CCR):

1. Title 24, Part 2: California Building Code (CBC).

1.5 CLASSIFICATION OF EARTHWORK

A. For specification purposes, earthwork shall be classified as follows:

B. Excavation - Common: All excavation involved in grading and construction of the trackway, parking areas, landscaped areas, walkways, roads, driveways, and connections thereto; and any other excavation classified or indicated as common excavation.

C. Excavation - Rock: Includes removal of material in place which cannot be loosened or broken down with one pass of a crawler tractor weighing not less than 55,000 pounds, with a maximum draw-bar pull of not less than 57,000 pounds-force, pulling a single 24-inch hydraulic ripper tooth approved by the tooth manufacturer for use with the tractor under full hydraulic down pressure, or equipment of equivalent ripping capacity.

D. Structure Excavation: The removal of material for the construction of foundations for aerial structures, bridges, buildings, retaining walls, headwalls, cut-and-cover subways, and other structures, and such other excavation indicated as structure excavation.

E. Structure Backfill: Structure backfill includes furnishing structural fill material, and placing and compacting structural fill material around structures to the lines and grades indicated. Structure backfill includes borrow excavation and material when required.

F. Fill for Raising Grade: Includes raising of subgrade or grade to indicated elevation with structural fill, including moisture-conditioning and compaction of placed fill material. Structural fill material includes borrow excavation and material when required.

G. Drainage Layer in Floodplain: Installed beneath the embankment in a floodplain. The drainage material also extends upward along the foreslopes to the estimated flood water level plus 1.5 feet.

H. Drainage Layer in Wet Areas: Installed beneath the embankment in areas where the water table is permanently or periodically at ground level. Structural Backfill: Includes furnishing, placing, and compacting structural fill material behind abutments, wingwalls, and retaining walls, as indicated.

I. Embankment Fill: Used only for embankment construction, above surrounding grade, and where there are no foundation-bearing concrete structures above. Embankment includes borrow excavation material when required.

J. Transition Zone Fill: Used for backfilling in reaches of earth embankment at transition zones between areas having different stiffnesses; for example, immediately adjacent to bridge and viaduct abutments, tunnels, cut-and-cover structures, culverts, and cut sections with an abrupt topographic change.

K. Subsurface Extraction: Includes removal of abandoned utilities, tanks, walls, foundations, and other miscellaneous subsurface man-made structures that interfere with new construction and are designated to be removed, and the cleaning of such items if they are indicated to be salvaged. Removal of such obstructions at or above grade is specified in Section 02 41 00, Demolition.

L. Salvaging Topsoil: Salvaging topsoil is the removal of topsoil to the depth indicated, stockpiling the material on-site, and maintaining the stockpile until the material is reused in the Work. Salvaging of topsoil shall be classified the same as the excavation with which it is associated, but if no classification can be made, it shall be classified as Excavation - Common.

1.6 SUBMITTALS

A. Permits: Submit copies of hauling and debris disposal permits and notices for record purposes. Include description of proposed haul routes.

B. Private Property Owner's Release: If surplus material removed from the site will be deposited on private property, submit two copies of written releases not more than 15 days before the start of work. Releases shall absolve the Authority from responsibility in connection with the depositing of material on private property, and shall be signed by the owners of such property on which the material will be deposited.

C. Delivery Tickets: Submit a delivery ticket with each load of imported borrow material delivered to the site, stating the type of fill material and the quantity.

D. Field Verification for In-Situ Treatment: Submit the proposed program for field verification of Standard Penetration Test "N" Values to be performed after in-situ treatment for mitigation of liquefaction potential.

E. Test Reports: Submit certified test reports of all tests specified to be performed by the Contractor. Test reports shall be sealed and signed by a California registered geotechnical engineer when required to meet requirements of the California Building Code.

1.7 REGULATORY REQUIREMENTS

A. Regulatory requirements that govern the work of this Section include the following governing codes:

1. California Code of Regulations, Title 8, Chapter 4, Subchapter 4 - Construction Safety Orders, and Subchapter 19 - Trench Construction Safety Orders.
2. California Code of Regulations, Title 24, Part 2, California Building Code, Chapter 33, Safeguards during Construction, and Structural Chapters 18 and 18A, Soils and Foundations.

1.8 QUALITY ASSURANCE

A. Tests: In accordance with the Contractor's Quality Management Plan, quality control tests shall be performed by an independent soils testing laboratory certified by Caltrans.

1.9 SITE CONDITIONS

A. Unfavorable Weather Conditions:

1. Do not perform excavation, filling, backfilling, and grading during weather conditions which might damage or be detrimental to the condition of existing ground, in-progress work, or completed work. When the work is interrupted by rain, excavating, filling, backfilling, and grading work shall not resume until the site and soil condition (moisture content) are suitable for compaction.
2. Subgrade shall be free from mud, snow, ice, and deleterious material when work is resumed.
3. Leave soil material that is too wet for compaction to drain. In addition to allowing soil material to drain, aerate and dry dried by disking and harrowing or other approved methods until the moisture content of the area is uniform and within the specified limits.

B. Prevention of Erosion:

1. Prevent erosion of stockpiles, ditches, embankments, filled, backfilled, and graded areas until such time as permanent drainage and erosion control measures have been installed.
2. Perform "protective grading" to provide positive drainage and to minimize ponding of surface water.

PART 2 - PRODUCTS

2.1 FILL AND BACKFILL MATERIALS - GENERAL REQUIREMENTS

A. Material used for fill, backfill, and embankment construction shall be an inert, inorganic soil, free from deleterious substances, and of such quality that it will compact thoroughly without the presence of voids when watered and rolled. Excavated on-site material will be considered suitable for fill, backfill, and embankment construction if it is free from organic matter and other deleterious substances and conforms to the requirements specified herein.

B. Excavated material that is suitable for fill, backfill, and embankment construction shall be conditioned for reuse and properly stockpiled for later filling and backfilling operations. Conditioning shall consist of spreading material in layers not to exceed 8 inches and raking free of debris and rubble. Rocks exceeding 3 inches in largest dimension and deleterious material shall be removed from the site and disposed of as specified herein under Disposal of Surplus Material.

C. Where conditions require the importing of fill or backfill material, the material shall be an inert soil or soil-rock material free of organic matter and meeting or exceeding the minimum requirements specified herein for the location.

D. All material to be used for filling, backfilling, and embankment construction requires written approval of the Contractor’s geotechnical engineer.

2.2 FILL AND BACKFILL MATERIALS - SPECIFIC REQUIREMENTS

A. Embankment Fill: Soils having the following mechanical properties and gradation:

1. Soil Group Classification per AASHTO, and ASTM D3282:

Acceptable (1)	**Unacceptable** (2)
A-1-a	A-4 (CBR <10)
A-1-b	A-2-7
A-2-4	A-5
A-2-5	A-6
A-2-6	A-7-5
A-3	A-7-6
A-4 (CBR >10)	*

* Rockfill is also not acceptable for track embankment material.

2. Maximum soil particle size limited to 3-inches.
3. Potential embankment fill source materials from groups A-2-7, A-5, A-6, and A-4 (with CBR <10) that can be modified using soil amendments or additives (cement, lime,

hydraulic binders, etc.) such that they be rendered suitable for use provided they meet all requirements of one or more of the soil group classifications among the list of 'Acceptable' materials per this specification. The modified soil, containing amendments or additives, shall be approved by Contractor's geotechnical engineer prior to use.

B. Structural Fill: Well to moderately-graded granular soils, as excavated, screened or blended, having the following mechanical properties and gradation:

1. Liquid Limit (ASTM D4318): 25 maximum
2. Plasticity Index (ASTM D4318): 6 maximum
3. Gradation (ASTM D422):

Sieve Opening	Percent Passing by Weight
1.5 inch square	100
U.S. No. 4	35 minimum
U.S. No. 30	20 minimum
U.S. No. 200	15 maximum

4. Sand Equivalent (Calif. Test 217): 20 minimum

C. Drainage Layer in Floodplain: The granular drainage material shall contain less than 5 percent fine-grained material (<No. 200 sieve) and comply with Terzaghi's filter criteria as summarized by Cedegren (1989):

$$\frac{D_{15}(filter)}{D_{85}(soil)} < 5 < \frac{D_{15}(filter)}{D_{15}(soil)}$$

and

$$\frac{D_{50}(filter)}{D_{50}(soil)} \leq 25$$

Where D15, D50, and D85 are the particle sizes at which 15, 50 and 85 percent, respectively, of the material by weight is smaller. D15(filter) denotes the D15 value for the filter material, D15(soil) denotes the D15 value for the fill or subgrade material in contact with the filter, and so forth. Additionally, the filter material should not be gap or broadly graded.

D. Drainage Layer in Wet Areas: This material shall not deteriorate or swell when immersed in water. It shall be well graded with no more than 10 percent passing the No. 200 sieve. The grading of the drainage material shall comply with Terzaghi's filter criteria against the subgrade original ground material as summarized by Cedegren (1989):

$$\frac{D_{15}(filter)}{D_{85}(soil)} < 5 < \frac{D_{15}(filter)}{D_{15}(soil)}$$

and

$$\frac{D_{50}(filter)}{D_{50}(soil)} \leq 25$$

Where D15, D50, and D85 are the particle sizes at which 15, 50 and 85 percent, respectively, of the material by weight is smaller. D15(filter) denotes the D15 value for the filter material, D15(soil) denotes the D15 value for the fill or subgrade material in contact with the filter, and so forth. Additionally, the filter material should not be gap or broadly graded.

E. Transition Zone Fill: For reaches of earth embankment supporting trackways at transition zones (immediately adjacent to bridge and viaduct abutments, tunnels, cut-and-cover structures, culverts, and cut sections with an abrupt topographic change) the "approach embankment" shall be constructed of Transition Zone Fill. This material shall have the following properties:

1. Shall consist of 96 percent to 97 percent Structural Fill (as outlined above).
2. Shall consist of 3 percent to 4 percent Portland Cement. The percentage of Portland cement shall be determined by mix design to meet strength requirements.
3. The strength of the Transition Zone Fill shall comply with the following:
   a. 7 days compressive strength > 290 psi
   b. 7 days tensile strength > 50 psi
   c. 28 days compressive strength > 440 psi
   d. 90 days compressive strength > 660 psi
   e. 90 days tensile strength > 90 psi
   f. 28 days immersed (14 days air curing following immersion in water for 14 days) compressive strength Ri/Rc > 0.75
4. For portland cement and water requirements refer to Section 03 05 15, Portland Cement Concrete.

2.3 MATERIALS FOR EARTHWORK

A. Fill and Backfill Materials: Where specific fill, backfill, and embankment materials are not indicated on Construction Drawings, conform to the following requirements:

1. Embankment Supporting Trackway: Embankment fill.
2. Backfill Against Concrete Walls and Waterproofing: Structural fill as indicated on the Construction Drawings.
3. Fill or Backfill Supporting Trackway at Transition Zones: Transition Zone Fill.
4. Backfill for Wing Walls, Retaining Walls, and Abutments: Structural fill or Transition Zone Fill as indicated.
5. Fill or Backfill under Supporting Walls and Columns and Similar Locations: Class 4000 concrete.
6. Backfill Where Not Otherwise Indicated: Embankment fill.

B. Topsoil to be Salvaged: Only existing topsoil which meets the requirements of Section 32 90 00, Planting, shall be salvaged. Topsoil that does not meet requirements specified shall be classified as Unsuitable Material and shall be removed from the site as herein specified under Disposal of Surplus Material.

2.4 SOURCE QUALITY CONTROL

A. Fill, backfill, and embankment materials proposed to be used in the Work shall be tested in the laboratory for compliance with specified requirements as follows:

1. Moisture-Density Relationship: ASTM D1557.
2. Moisture Content: ASTM D2216.
3. Liquid Limit: ASTM D4318.
4. Plastic Limit and Plasticity Index: ASTM D4318.
5. Percentage of Wear: ASTM C131 or C535, as applicable.
6. Sieve Analysis: ASTM D422, and ASTM C136, as applicable.
7. Percent Passing No. 200 sieve: ASTM D1140.
8. Sand Equivalent: California Test 217.
9. Organic Content of Soils: ASTM D2974.
10. California Bearing Ratio: ASTM D4429 (in-place), or ASTM D1883 (laboratory).

B. Where classification of soils is necessary to meet specified requirements, perform laboratory tests in accordance with ASTM D2487 and AASHTO soil classification criteria (summarized in ASTM D3282).

C. Submit certified test reports of all tests as specified under the Article entitled “Submittals” herein.

PART 3 - EXECUTION

3.1 STAKING AND GRADES

A. Lay out the work, establish all necessary markers, bench marks, grading stakes, and other stakes as required, in accordance with the requirements specified in Section 02 21 23, Field Engineering.

B. Comply with the requirements of Section 31 09 13, Geotechnical Instrumentation and Monitoring.

3.2 EXISTING UTILITIES

A. Refer to Section 33 05 25, Support and Protection of Utilities, for detailed requirements. Verify on site the location and depth (elevation) of all existing utilities and services before performing any excavation work. Perform excavation within 3 feet of an active utility line by hand.

B. Abandoned sewers, piping, and other utilities encountered in the progress of the excavating shall be removed and the ends plugged.

C. Active utility lines encountered, which are not indicated in the Contract Documents, shall be reported immediately to the Contracting Officer and utility owners involved. Utility owners shall be permitted free access to such utility lines.

3.3 EARTHWORK GENERAL REQUIREMENTS

A. Provide excavation for trackway and pavement; excavation and placement of compacted fill and backfill for structures, cut-and-cover subways, and subsurface and surface drainage; placement of drainage layer backfill; construction of embankments; subgrade and foundation preparation; subsurface extraction of miscellaneous structures and facilities indicated or required to be removed; and finish grading.

B. Dust Control: Control dust. Refer to other Contract requirements for additional requirements.

C. Erosion Protection: Prevent erosion of the site at all times. Construct temporary berms and dikes and cut temporary swales to promote natural drainage of site.

D. Construction Traffic: Disperse travel paths of traffic and construction equipment over entire width of compacted surfaces so as to aid in obtaining uniform compaction. Protect exposed soil layers with high moisture content from excessive wheel loads.

E. On-Site Excavation or Borrow Pits: Do not excavate or remove any material from the project site or right-of-way which is not within the designated excavation, as indicated by the slope and grade lines, without written authorization from the Contractor's engineer.

F. Salvaging Topsoil:

1. Salvage topsoil from stripped and excavated areas, and stockpile on the site at appropriate locations. Prevent topsoil from contamination by other materials, and provide adequate drainage and erosion protection.
2. Place stockpiled topsoil in areas indicated to be landscaped on the Construction Drawings.

G. Stockpiling of Fill and Backfill Material:

1. Excavate and separately stockpile suitable fill and backfill material, as indicated, during the progress of the excavation work. Save sufficient suitable excavated material, if available, for later filling, backfilling, and embankment construction.
2. Store materials from required excavations that are suitable for fill, backfill, and embankment as excavated, in stockpiles segregated by type.
3. Establish excavated material stockpiles on site only in locations where they will not interfere with the progress of the Work. Offsite stockpiling, if necessary, shall be the responsibility of the Contractor.

H. Disposal of Surplus Material:

1. Excess earth materials, unsuitable materials, and debris shall become the property of the Contractor and shall be removed from the site and disposed of in a legal manner.
2. Location of disposal site and length of haul shall be the Contractor's responsibility.

I. Maintenance of Excavations, Slopes, and Embankments:

1. Excavate and remove material outside the limits of the excavation which is unstable and constitutes potential slides, and material which comes into excavations for any reason including from the driving of piles.

2. Maintain slopes and embankments until substantial completion and acceptance of the Work. Promptly repair slides, slipouts, washouts, settlements, and subsidence that occur for any reason, and refinish the slope or embankment to the indicated lines and grades.
3. Refer also to Section 31 35 00, Slope Protection, for requirements.

J. Safeguarding of Structure Walls: Take precautions necessary to ensure that structure walls are not damaged as a result of heavy equipment being operated in their proximity. At minimum, heavy equipment and rollers greater than one ton shall not be operated within 4 feet of structure walls.

3.4 SUBSURFACE EXTRACTION

A. Remove subsurface facilities and obstructions to the extent indicated.

B. When subsurface facilities are encountered during excavation, which interfere with new construction, and such facilities are not indicated, notify the Contracting Officer and Contractor's engineer promptly for corrective determination.

3.5 ROUGH GRADING AND FILLING

A. Prior to commencement of earthwork, perform such soil and rock removal and filling as may be required to facilitate the progress of the Work and bring all elevations to the rough grading lines indicated on the Construction Drawings. Grading shall be performed by blading or as herein specified under Article entitled "Subgrade Preparation" herein.

B. Fill or backfill, test pits, or holes which will not be completely removed by excavation, with lean concrete, drainage layer backfill, or clean structural fill, and compact as herein specified in layers not exceeding 8 inches in uncompacted thickness.

C. Fill or backfill holes, swales, and low points that will not otherwise be removed in the course of the work to the indicated grades.

3.6 EXCAVATION

A. General Excavation Requirements:

1. Perform excavating as indicated and required for trackway and roadway beds, for concrete footings, foundations, retaining walls, exterior paving, floor slabs, concrete walks, and for site levels and grading, and provide shoring, bracing, underpinning, cribbing, pumping, and planking as required.
2. Comply with applicable requirements of CCR, Title 8, Trench Construction Safety Orders.
3. The bottoms of excavations shall be level, firm, undisturbed earth, clean and free from loose material, debris, and foreign matter.
4. Excavate to the lines and grades indicated on the Construction Drawings.
5. Excavations shall be supported and maintained by providing structural support of earth walls as specified in Section 31 50 13, Temporary Excavation Support and Protection, so that sides are stable and will not move. Excavations may be maintained by sloping cut faces where space permits, if calculations show that the slopes are safe. Such calculations shall be sealed and signed by a civil or structural engineer currently registered in the State of California. Calculations shall consider all existing conditions, including adjacent traffic, construction loading, and other local effects.

6. Limits of excavations shall allow for adequate working space for installing forms, wall waterproofing, and as required for safety of personnel. Cut excavations in solid rock accurately to the lines indicated on the Construction Drawings, or to the width of the ductbank or concrete encasement.
7. Dewater excavation as specified in Section 31 23 19, Dewatering. Construct berms around excavations as required to prevent surface water and runoff from entering the excavation.
8. Remove unstable bottom material. Remove large stones, debris, and compressible soils from excavation bottoms to a minimum depth of 12 inches. Where required to excavate to rock, it shall be understood to mean sound bedrock. Remove loose and unsound material.
9. Except as otherwise indicated, preserve the material below and beyond the lines of excavations. Where an excavation is carried below the indicated grade, backfill to the indicated grade as herein specified.
10. Obtain the Contracting Officer's written acceptance prior to performing excavations for convenience of the Contractor.
11. Fill unauthorized over excavations for footings and foundations filled with lean concrete to indicated elevations.
12. Place excavated material at a sufficient distance from edge of excavation so as not to cause cave-ins or bank slides, but in no case closer than 3 feet from the edge of excavations.
13. Excavated earth material that is suitable for fill, backfill, or embankment shall be conditioned for re-use and properly stockpiled for later filling and backfilling operations as herein specified. Test, screen, and mix as necessary to meet specified requirements.

B. Rock Excavation:

1. Rock which cannot be broken up and removed by ripper equipment shall be excavated and removed by drilling and blasting. Perform blasting in accordance with the requirements of jurisdictional authorities. Obtain the required permits prior to the use of explosives.
2. Use pre-splitting to establish a shear plane in the rock along the cut periphery or proposed break lines to reduce overbreakage. Pre-split a periphery plane to the depth to be excavated prior to other blasting within the limits of that particular plane; except that the Contractor will not be required to pre-split to slopes flatter than one-to-one. Pre-split by drilling appropriately sized holes at intervals of not more than 3 feet, to the depth of the cut, along the plane of the proposed cut; load and stem such holes with an appropriate light charge explosive, and detonate all holes in the particular plane simultaneously.
3. If the depth of the cut is more than can be drilled from the top, an 18-inch offset will be allowed in the slope to begin succeeding drilling operations. The end result shall be a relatively smooth shear plane with localized irregularities which do not exceed 2 feet behind or 1 foot in front of the shear plane surface and which do not extend within the indicated lines of the excavation.
4. Where footings or foundations are to be placed on rock which is not horizontal, key the center of the foundation approximately 12 inches in depth throughout an area approximately equal to the dimensions of the column or footing to be placed on the rock, or the entire width of the slab, at not more than 10-foot intervals. Remove loose fragments, and clean and fill all seams with lean concrete.
5. Material excavated beyond or below the indicated cross section shall be at the Contractor's expense. Fill overbreakage to required invert with lean concrete at no additional expense to the Authority.

6. Leave the side slopes of rock cuts with reasonably uniform faces whether the excavation is carried beyond the specified side slopes or not. Remove all loose rock on cut slopes immediately after blasting. Sloped surfaces shall conform to the typical section indicated or to natural cleavage planes, where these are compatible with the typical section.
7. Exposed rock faces shall be mapped by a Contractor-employed, California-registered geotechnical engineer or engineering geologist. If structural mapping indicates that unstable planes or other features are exposed which jeopardize the stability of the slope, the Contractor shall modify the slope as required.

3.7 EMBANKMENT CONSTRUCTION

A. Construct embankments to lines, grades, and contours indicated, in layers as nearly uniform and horizontal as is consistent with the indicated finished contour and profile. Maximum thickness of the layers shall be 8 inches before compaction.

B. Compact each layer to specified density for entire width of the embankment. Achieve required compaction by rolling with compaction equipment suitable for type and condition of the particular material. Roll in a longitudinal direction parallel to longest dimension, starting at outer edges and progressing toward the center.

C. Moisture-condition embankment fill material as required to achieve its compaction to the specified density, within the tolerances specified herein.

D. Do not compact material that contains excessive moisture. In such cases, scarify to the full depth of the layer having excessive moisture content and dry by reworking, mixing with dry materials, or other methods approved by the Contractor's geotechnical engineer.

E. Remove material that cannot be compacted to required density within specified tolerances, and replace with suitable material.

F. Where pipes, culverts, or structures extend into embankments, construct embankment to at least 2 feet over and 10 feet on either side of the pipe, culvert, or structure location prior to excavation.

G. Where fill is to be placed against hillsides or slopes or where a new fill is to be placed against an existing embankment, the slopes of the original hillside or existing embankment shall be benched in order to provide a notched interface between the new fill and the existing ground. Bench widths are expected to be variable depending on the slope angle, however bench heights shall be limited to approximately 4 feet. A keyway shall be excavated to provide support for the toe of new fill slopes constructed against slopes.

H. Do not commence final shaping until above specified requirements have been completed. Shape entire surface of the slopes of cuts and embankments to true grade, alignment, and cross section indicated. Leave cut slopes in rock with uniform surface, and remove all loose overhanging rock.

3.8 SUBGRADE PREPARATION

A. Perform all cutting, blading, and shaping as required to cut and shape the subgrade to the grades and elevations indicated.

B. Subgrade preparation includes fine grading, reworking as necessary, and preparation of cut, fill, or embankment upon which the structure and equipment foundations, pipe, sub ballast, sub base, base, and pavement will be placed. Remove unsuitable subgrade material, such as weak or compressible soils.

C. Scarify and mix entire surface of subgrade to a depth of at least 6 inches. Moisture-condition scarified subgrade to 3 percent above optimum moisture content. If subgrade stabilization material is required, incorporate it into the subgrade at this time.

D. After the material has been thoroughly mixed and moisture-conditioned, accurately construct and fine grade the subgrade to indicated line, grade, and contour with high and low spots eliminated. Compact for full width to the specified density. Remove soft spots developed during working, fill with materials specified in this Section, and re-compact.

E. Finish subgrade to straightedge or template within specified tolerances with the finished surface bladed to a uniform, dense, smooth texture.

3.9 FOUNDATION PREPARATION

A. Complete construction of the excavation support and dewatering systems prior to construction of structure and equipment foundations.

B. Avoid disturbing bottom of excavation. If bottom is disturbed, restore and stabilize the bearing foundation with compacted structural fill material as specified herein.

C. If material at bottom of the excavation is rock, remove loose material and roughly level the bearing foundation to indicated elevation. If the bottom contains occasional rock outcroppings or rock in only a portion of the area, remove such rock to a depth of 6 inches below indicated subgrade and backfill with lean concrete.

D. Where unsuitable material is encountered at the elevations indicated for foundations, all soft, loose, or unsuitable material shall be removed. The area shall be scarified to a minimum depth of 12 inches, and the planned elevation shall be re-established by backfilling with structural backfill, moisture-conditioning, and compacting to a minimum dry density of 95 percent of the maximum laboratory dry density as determined in accordance with ASTM D1557. Where the exposed foundation consists of competent, undisturbed in-place soils, scarifying may be omitted.

3.10 SUBGRADE FILLING/RAISING GRADE

A. Compacted fill for raising of subgrade to indicated elevation shall be constructed as specified in this Section. Fill material shall be spread in uniform lifts not exceeding 8 inches in uncompacted thickness. Fill material that does not contain sufficient moisture to compact properly shall be sprinkled with water; if it contains excess moisture it shall be aerated or permitted to dry to the proper water content. Fill material and water shall then be thoroughly mixed before being compacted. Each layer of spread fill material shall be compacted to the specified density.

B. Control of fill shall consist of field inspection and testing to determine that each layer has been compacted to the required density and to ensure that optimum moisture is being obtained. Any layer or portion of a layer that does not attain the compaction required shall be scarified and re-compacted until the required compaction is obtained.

C. Spreading and compacting shall be performed as required to produce the required density and a uniform surface smooth and true to grade.

3.11 COMPACTION

A. Compaction Density: Compact each layer of embankment, fill, and backfill material to not less than the indicated or specified compaction. Required compactions are defined as Class I and Class II, as follows:

1. Class I Compaction: 90 percent relative compaction as determined by ASTM D1557.
2. Class II Compaction: 95 percent relative compaction as determined by ASTM D1557.

B. Required Compactions:

1. Embankment or fill where the surface will be bearing foundation: Class II for full depth. Where embankment construction exceeds 5 feet in depth, provide minimum Class I compaction below the top 3 feet.
2. Fill Below Trackways and Pavements: Class II for full depth.
3. Backfill around Structures: Class I under top 12 inches; Class II for top 12 inches.
4. Cut-and-Cover Backfill: Class I to 36 inches above structure or utility; Class II for balance, with a minimum of Class II for top 12 inches.
5. Original Ground or Cut Subgrade: Except as specified in Articles entitled “Subgrade Preparation” and “Foundation Preparation” where original ground or cut subgrade, or fill less than 1 foot thick, will be subgrade or bearing foundation, scarify the surfaces and provide Class II compaction for at least 8 inches in depth. Include the following additional requirements:
   a. Provide Class II compaction for original ground when such original ground is within 3 feet of top of rail profile, for full width of trackway plus three feet on each side thereof.
   b. Provide Class II compaction for top 12 inches of undisturbed original ground upon which embankments are to be constructed.
6. Where not otherwise indicated or specified and where structures are not involved, provide Class I compaction to minimize settlement.

3.12 BACKFILLING

A. Use materials removed from site excavations if such material meets specified requirements.

B. Backfilling is required around all substructures. Fill all abandoned vaults, shafts, airways, adits, holes, pits, and other voids.

C. Place backfill in layers not to exceed eight inches of loose material, and compact each layer to specified density before the next layer is placed.

D. Place backfill material in such manner that unbalanced horizontal loads will not be applied to a newly placed structure or portion of structure, utility, or pipeline. Do not backfill around portions of structures requiring backfill on only one side or on less than all sides, until the concrete has reached the specified 28-day strength to withstand the earth pressures on structures.

E. When placing material for backfill around waterproofed structures, protect such structures and the waterproofing thereof with a shield when necessary to prevent displacement or injury by stones or other hard substances in the backfill.

F. Do not backfill on or against structural concrete until the specified 28-day concrete strength has been attained.

G. Complete backfill for end bents and abutments, including backfill for wingwalls, in accordance with the above specified time/strength limit. Step slopes behind abutments, unless otherwise indicated, to prevent backfill from acting as a wedge against the abutment. Provide drainage behind abutments and wingwalls as indicated.

H. Do not use compaction equipment and methods that produce excessive horizontal or vertical earth pressures on structures. Excessive horizontal earth pressures are those in excess of at-rest earth pressures. Excessive vertical earth pressures are those in excess of overburden pressures.

3.13 FINISH GRADING

A. Finish grade all areas to elevations and grades indicated. In areas to receive topsoil and landscape planting, finish grading shall be performed to a uniform 7 to 8 inches below the grades and elevations indicated.

B. Place and spread stockpiled topsoil to a uniform thickness of 6 inches (approximately) in areas to receive topsoil and landscape planting. Place and spread to a uniform thickness approximately 1 inch below finish grade indicated.

C. Coordinate with the requirements of Section 32 90 00, Planting.

3.14 TOLERANCES

A. Construct finished surfaces to plus or minus 1/2-inch of the elevations indicated.

B. Complete embankment slopes to plus or minus 4 inches of the slope line indicated. Do not encroach on the trackway bed or roadbed.

C. Maintain the moisture content of fill material as it is being placed within plus or minus two percent of the recommended optimum moisture content of the material.

3.15 FIELD QUALITY CONTROL

A. Quality Control: The Contractor shall provide quality control measures to ensure compliance with specified requirements. Foundation and subgrade preparation and the placement and compaction of fills shall be performed under the surveillance of a California registered geotechnical engineer employed by the Contractor, as required to comply with the California Building Code, Chapter 33 and Appendix Chapter 33 and Chapters 18 and 18A.

B. Regulatory Requirements: In compliance with the California Building Code, Chapter 33, the Contractor's earthwork operations shall be performed under the observance and inspection of a Contractor-employed geotechnical engineer currently registered in the State of California, as follows:

1. Site preparation, cutting and shaping, excavating, filling, backfilling, and embankment construction shall be carried out under the inspection of the Contractor's geotechnical

engineer, who will perform appropriate field and laboratory tests, as determined by the Contractor’s geotechnical engineer, to evaluate the suitability of fill and backfill material, the proper moisture content for compaction, and the degree of compaction achieved. Fill or backfill that does not meet the specified requirements shall be removed or recompacted until the requirements are satisfied.

2. Cutting and shaping, excavating, conditioning, filling, backfilling, and compacting procedures require approval of the Contractor’s geotechnical engineer as they are successively performed. Work found to be unsatisfactory or work disturbed by subsequent operations before approval is granted shall be corrected in an approved manner as approved by the Contractor’s geotechnical engineer.

C. Density Tests: Compacted fill, backfill, and embankment shall be tested to verify compliance with specified requirements in accordance with ASTM D6938. Frequency of tests shall be in accordance with the Contractor's Quality Plan and Section 31 09 13, Geotechnical Instrumentation and Monitoring, but not less than the following:

1. Expansive Horizontal Areas: One test per 100 cubic yards, or fraction thereof, of fill or backfill placed.
2. Confined Areas and Embankments: One test per every second lift of fill, backfill, or embankment placed.

D. Compaction Tests: Tests for compaction shall be performed in accordance with test procedures specified in ASTM D1557, Method D, as applicable. Field-testing of soils or compacted fill in place shall be performed in accordance with applicable requirements of ASTM D6938.

E. Moisture Content Tests: Compacted fill, backfill, and embankment shall be tested to verify compliance with specified requirements in accordance with ASTMD6938. Minimum frequency of tests shall be as specified above for density tests.

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SECTION 31 09 13

GEOTECHNICAL INSTRUMENTATION AND MONITORING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Geotechnical instrumentation and monitoring.

1.2 DEFINITIONS

A. Survey control is defined as a system of precise field measurements of the types specified herein, utilizing acceptable methods, equipment, and qualified personnel for determination of elevations, coordinates, and distances.

B. Instrumentation includes boreholes, casings, inclinometers, multi-point borehole extensometers (MPBX), tape extensometers, deep benchmarks, deep and shallow settlement reference points, liquid tube and vibrating wire (VW) settlement systems, tilt meters, strain gauges, crack gauges, load cells, observation wells, piezometers, probes, supplies, wires, protective casings and covers, data loggers, readouts and other devices to monitor ground movements, settlements, horizontal displacements, vertical displacements, loads, and groundwater.

C. Initial instrument monitoring includes determination of actual installation plan locations and elevation for all instruments and monitoring points as well as the initial reading for the installed instrument.

D. Baseline reading is the reading that is based on a series of formal initial readings and is the one with which all subsequent readings shall be compared to determine magnitude of change.

E. Interpretation is defined as including screening of data for correctness, identifying and confirming instrumentation data trends, identifying anomalies, comparing individual instrument data with other data, relating data to construction activities, and determining if potential problems are developing.

F. Unless otherwise noted, the position of the tunnel refers to the face of excavation at the leading edge of the tunnel.

1.3 REFERENCED STANDARDS

A. ASTM International (ASTM):

1.	ASTM A36/A36M	Standard Specification for Carbon Structural Steel
2.	ASTM A48/A48M	Standard Specification for Gray Iron Castings
3.	ASTM A53/A53M	Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
4.	ASTM D1586	Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils
5.	ASTM D1785	Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedule 40, 80, and 120

6.	ASTM D2487	Standard Classification of Soils for Engineering Purposes (Unified Soils Classification System)
7.	ASTM D2488	Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)
8.	ASTM D5434	Standard Guide for Field Logging of Subsurface Explorations of Soil and Rock

1.4 SYSTEM DESCRIPTION

A. The Contractor is responsible for instrumentation and monitoring to protect the existing and new structures, facilities, and utilities.

B. This Section specifies basic and minimum standards for geotechnical instrumentation and monitoring of earthwork and structures.

C. For purposes of this Section, geotechnical instrumentation shall consist of movement detection instruments, internal bracing and anchor load instrumentation, and groundwater monitoring devices.

D. Design, furnish, install, maintain, and remove geotechnical instrumentation systems for the monitoring of fill, embankments, and open-cut, cut-and-cover, and tunnel excavations; structures and utilities; loads in structural elements for the support of excavations; and pore water pressures and groundwater levels. Provide geotechnical instrumentation specified herein during fill and embankment placement; cut slope, open-cut, cut-and-cover, and tunnel excavations; underpinning installation and related excavation; and other elements of the Work including demolition activities and pile driving.

E. Evaluate the instruments required to detect the movement of ground and structures during construction. Wherever the words “or approved equivalent” or “or similar” is used in regard to specific products, it shall be understood that the approval of an alternative product shall be by the Contractor’s geotechnical engineer.

F. Develop an instrument monitoring system intended to provide early information to permit timely implementation of proper remedial measures, when and as required, to prevent damage to structures, facilities, and utilities.

G. Locate instruments, and design and implement monitoring program to document the ground movement, if any, that takes place during excavation, fill placement, and construction of structures.

H. Locate settlement reference points and crack gauges on and about any structure which may be affected by excavation performed as part of the Contract. Design and implement monitoring program to document any horizontal or vertical movement of structures.

I. Determine exact location of the instruments including settlement reference points to be installed in the field with the approval of the Contractor’s geotechnical engineer and the acceptance of Contracting Officer.

J. Commence monitoring of existing conditions for movement 12 months prior to the start of construction activities. Monitoring of existing conditions shall include existing structures and other facilities. If construction activities will commence earlier than 15 months following the

Notice to Proceed, commence monitoring no later than 120 days following the Notice to Proceed. Monitor for a longer period prior to construction at the discretion of the Contractor.

K. If the design has not progressed to a point where location and type of monitoring can be determined when monitoring is required to commence, select and locate monitoring devices based on the most disruptive construction methods and footprint.

L. Determine threshold and limiting values for ground distortions. Be responsible for interpretation of instrumentation data as input to evaluating construction and excavation performance and controlling settlements to prevent damage to structures, facilities, and utilities.

M. Implement remedial measures, including modification of construction procedures, as necessary.

1.5 SUBMITTALS

A. Shop Drawings: A minimum of 60 days before installation, submit shop drawings of each instrument including: location, layout, existing subsurface utilities, and details necessary to install, maintain, monitor, and remove that instrumentation. Show proposed locations at a maximum scale of 1 inch equals 40 feet, and describe instrumentation components. For longer sections, a larger scale may be used with details provided at no larger than 1 inch equals 40 feet. Indicate methods of installation and maintenance for instrumentation systems.

B. Documentation:

1. Submit proposed forms to be used for recording observations, and monitoring and reporting of data. Submit a sample showing proposed format for recording of readings, calculations, and plots.
2. Submit manufacturer's catalogs and printed installation instructions for instruments furnished.
3. Submit, within 24 hours of completion of equipment installation, three copies of installation notes, initial readings, and monitoring data taken immediately after installation. Submit field borehole logs within 48 hours of completion.
4. For each instrument, submit final installation notes, typed logs of borings, and lab testing, as applicable, within 10 days of installation.
5. Submit as-built drawings showing surveyed instrumentation and settlement reference points at a maximum scale of 1 inch equals 40 feet.

C. Certification:

1. Submit certification of equipment manufacturers, supervision, installation crews, and monitoring personnel at least 60 calendar days prior to installation.
2. Submit certification of equipment calibration.

D. Monitoring Documentation:

1. Within 12 hours after monitoring any instruments, submit:
   a. A copy of the data sheet containing a cumulative history of all readings, including weather conditions at time of each reading
   b. A copy of the plot of measured value versus time, which also includes a time history of construction activity likely to influence such readings (e.g., depth of excavation, height of fill, presence of heavy equipment on or near decking, etc.)

2. Submit weekly a brief narrative of instrumentation activity for the preceding week in a format proposed by the Contractor's geotechnical engineer and accepted by the Contracting Officer.
3. Submit samples as specified.

E. Mix Designs: Submit proposed borehole instrument grout mix designs.

F. Closure Report: Upon removal of instrumentation, submit a report certifying that removal of the upper casings, plugging of holes, and restoration of surfaces has been accomplished as specified and, where applicable, abandoned in accordance with applicable codes and regulations.

1.6 OBJECTIVES OF MONITORING

A. To detect movements; to determine loads, stress, and strains in structural members; to detect changes in pore water pressures in soil and rock; to provide reliable information to foresee problems; and to predict the range of structure instability and ground movement

B. To monitor settlements and movements of existing structures prior to and during construction to verify satisfactory performance

C. To detect excessive loading in individual members used for internal bracing, or other temporary support

D. To verify the performance of earth structures and other structures, such as settlement and pore pressure dissipation beneath embankments on soft soil

E. To measure convergence between opposite points of tunnel cross sections so as to evaluate the stability of the tunnel opening and to verify that movements have stopped before final lining is placed

F. To provide early information to permit timely implementation by the Contractor of proper remedial measures, as required, to prevent damage to structures, equipment, and utilities and to maintain the safety of personnel and the Work. Remedial measures may include modification of construction procedures

1.7 QUALITY ASSURANCE

A. Qualifications:

1. Manufacturer: Select a firm regularly engaged in the manufacture of monitoring instrumentation of the type specified herein.
2. Equipment: Incorporate into the Work a geotechnical instrumentation system which consists of products and elements found to have provided satisfactory results in similar projects and has been in use for a period of five years prior to its use in the Work.
3. Personnel:
   a. Employ a Geotechnical Engineer or Engineering Geologist, licensed in the State of California and experienced in installation of instruments of the type specified in this Section, to supervise and direct instrument installation technicians and to be responsible for instrument installation monitoring, reduction, and interpretation of instrumentation monitoring data.

b. Employ qualified installation technicians who have adequate previous experience in installation of instruments of the type specified herein.
c. Employ qualified technicians working under the direction of the Geotechnical Engineer or Engineering Geologist who have previous experience in supervision and monitoring instruments of the type specified in this Section.
d. Qualified personnel, whose qualifications are specified herein, shall be available on site at all times during the Work that would affect geotechnical instrumentation.

B. Survey Control: Refer to Section 02 21 23, Field Engineering.

1. Employ qualified technicians or a specialist subcontractor for survey control with experience in performing control surveying of the type specified in this Section.
2. Employ a land surveyor or a specialist subcontractor thoroughly experienced in survey control of the type specified in this Section to supervise and direct survey control technicians and to be responsible for the survey control.

C. Tolerances:

1. Survey to Second Order, Class I minimum accuracy.
2. The initial coordinates of each instrument, except for load cells and strain gauges, shall be to 0.01 ft.
3. The elevations of settlement reference points shall be to 0.001 ft.

PART 2 - PRODUCTS

2.1 MOVEMENT DETECTION INSTRUMENTATION - INCLINOMETERS

A. Inclinometer Casings: Provide semi-rigid acrylonitrile-butadiene-styrene (ABS) plastic for installation in the ground, having a nominal outside diameter not greater than 3.34 inches and not less than 2.75 inches, internally grooved to receive inclinometer probe, manufactured by Slope Indicator Co., or similar by Geokon, Roctest, Inc., or RST Instruments, Inc., or approved equivalent.

B. Casing: Provide in minimum lengths of 10 feet. Shorter lengths are acceptable to complete installations. Provide casing with four internal longitudinal grooves, equi-spaced. Provide alignment of the grooves equal to or better than 1 degree in 10 feet.

C. Couplings, Locking Devices and Caps: Provide sizes and types recommended by the casing manufacturer.

D. Grout: Provide grout in accordance with manufacturer's recommendations.

E. Ground Surface Protection:

1. Inclinometer casings within unpaved work areas: Provide an 8-inch-diameter, above-ground steel casing with a removable cap for protection at the top.
2. Inclinometer casings within paved areas: Provide a traffic cover of size indicated. Provide lifting rod or pull-up device for lifting top cover.

F. Inclinometer Probes and Readout Indicators: Furnish in numbers to ensure the constant availability of functioning units on the site in case of loss or failure of prime units.

G. Inclinometer Probes: Provide 24-inch wheel-based Digitilt Inclinometer Probe Model 50302500 (English), and Digitilt Datamate Model 50310900, and DMM software Model 50310970 manufactured by Slope Indicator Co., or similar, by Geokon, Inc., RST Instruments, Inc., Roctest, Inc., or approved equivalent, and at least 150 feet of waterproof cable or of sufficient length to monitor deepest inclinometer with external marks at 1-foot intervals, pulley assembly with cable holds and cable reels, and other accessories associated with the instrument.

2.2 MOVEMENT DETECTION INSTRUMENTATION - BOREHOLE EXTENSOMETERS

A. Provide multiple-position borehole extensometers to measure subsurface settlement. Each extensometer shall be suitable for reading both with a mechanical readout and also with vibrating wire transducers, as required, and shall include the following components:

1. Anchors
2. Rods
3. Protective sleeving
4. Reference head
5. Electrical cable
6. Mechanical readout unit
7. Portable vibrating wire readout unit
8. Datalogger

B. Drill holes shall be of a diameter recommended by the manufacturer to accommodate the number of anchors and remote readout head scheduled for each instrument, as applicable. Anchors shall be suitable for grouting in place.

C. Rods shall be 1/4-inch stainless steel or approved equivalent. Rods shall comprise 5-foot or 10-foot lengths, except for shorter lengths needed to create required total rod lengths.

D. Protective sleeving shall comply with ASTM D1785.

E. Reference heads shall conform to the following requirements:

1. The reference head shall accommodate the number of rods identified for each extensometer.
2. Transducers shall be vibrating wire transducers. They shall be fully waterproof with a range of not less than plus or minus 4 inches. Range adjusters shall be used to increase the range, if necessary. Accuracy shall be plus or minus 0.1 percent of the range. The transducers shall be attached to the rods in a way that permits easy installation and adjustment of the transducers. Provisions shall be made for temperature measurements in each extensometer head for use in making corrections to transducer readings. A facility to check, the instruments shall be included using a mechanical readout unit consisting of a depth micrometer or an analog dial gauge. Each mechanical readout unit shall be provided with a calibration standard.
3. The transducers shall be wired so that they can be read both by the datalogger and the portable readout unit. Each Multi-Position Borehole Extensometer (MPBX) shall be connected to a datalogger. The portable readout unit shall be used during installation and for subsequent readings.
4. Reference heads shall be protected against dirt and drainage by specially designed lockable covers.

5. Electrical cable shall be as recommended by the manufacturer and shall be a shielded twisted pair with a waterproof jacket.
6. Cement grout shall be as recommended by the manufacturer.
7. Factory calibrations of transducers shall be made by moving the core of each transducer a minimum of 10 known amounts through its range, in two full cycles, in and out, using gauge blocks or a micrometer to measure its movement. The measured movement shall be compared with the indicated movement on the readout unit. Calibrations shall be made over two complete movement cycles. A thermal factor shall be provided for each batch. Transducers shall be rejected if comparative readings between cycles vary by more than plus or minus 0.002 inch.

2.3 MOVEMENT DETECTION INSTRUMENTATION - TAPE EXTENSOMETERS

A. Provide tape extensometer system Model 51811500 and anchor points Model 51812000 for the measurement of change in tunnel diameters, manufactured by Slope Indicator Co., or Model 1610 manufactured by Geokon, Inc., Model EXTE 0020 manufactured by RST Instruments, or approved equivalent.

B. Provide eye bolt for attachment to the tunnel lining that is compatible with the tape extensometer. Use a method of attachment in accordance with manufacturer's recommendations and suitable for the type of lining installed.

C. Provide tape extensometer standard of nominal length equal to tunnel diameter and conforming to ASTM A36/A36M structural steel.

D. A laser Electronic Distance Measurement (EDM) system with appropriate targets is an acceptable option instead of a tape extensometer. EDM equipment used for horizontal movement monitoring shall, after calibration, have a minimum accuracy of plus or minus 0.02 inches.

2.4 MOVEMENT DETECTION INSTRUMENTATION - DEEP BENCHMARKS

A. Provide outer casings having a nominal diameter of 2 1/2 inches and inner pipes having a diameter of 1- 1/2 inches, steel pipes conforming to ASTM A53/A53M, welded, standard weight.

B. Provide couplings or steel spiders to center inner pipe.

C. Provide heavy grease at couplings or spiders.

D. Provide benchmark tops of necessary components, including a suitable centering device between inner benchmark and outer casing.

E. Provide a read point consisting of a ball fabricated from suitable grade of stainless steel.

F. Provide sand-cement grout containing three parts sand to one part cement by weight, with a water-cement ratio not to exceed 0.5.

G. Provide traffic cover of size and type indicated in the Part 2 Article entitled “Traffic Covers” herein.

2.5 MOVEMENT DETECTION INSTRUMENTATION - SHALLOW SETTLEMENT REFERENCE POINTS

A. Shallow settlement reference points include shallow subsurface settlement points, ground surface settlement points, and building settlement reference points.

B. Structural Surfaces:

1. Provide settlement reference points that are decals, graduated tape strips, scribe marks, concrete nails, Parker-Kalon (PK) nails, pins, optical targets, or combinations thereof.
2. Provide three-piece expansion anchors consisting of an outer lead alloy sleeve, an inner lead alloy wedge nut, and a stainless steel cap head bolt. Adjust for horizontal or vertical installation as field conditions require and as approved by the Contractor's geotechnical engineer. Provide graduated strips on columns.

C. Ground Surfaces:

1. In areas that are not paved but which may be subject to light traffic, provide metal plugs and capped pipe embedded in 6-inch by 6-inch-wide by 8-inch-deep concrete.
2. In areas protected from traffic (including construction traffic) where no pavement or structure exists, provide 2-inch by 2-inch hardwood stake with PK nail as a reference point.
3. Provide reference points that are chisel marks, concrete nails, round-headed bolts for precision, or combination thereof, as field conditions require on street curbs, basement slabs, and pavements.
4. Provide protective housing of 4-inch inside diameter steel pipe and flush lid for heavy traffic areas where reference points are at least 1 inch below surface.

2.6 MOVEMENT DETECTION INSTRUMENTATION - DEEP SUBSURFACE SETTLEMENT INDICATORS

A. Provide deep subsurface settlement indicators consisting of steel pipe casing of 3-inch outside diameter and 1-inch inside diameter black steel pipe conforming to the requirement of ASTM A53, welded extra strong; stainless steel pipe cap for read point; 1/8-inch steel plate for spiders; 1/2-inch thick by 6- inch-diameter steel plate for cover; grease and oakum packing for annular space; and assembled in accordance with the approved shop drawings.

B. Provide protective ASTM A48/A48M, Class 30, cast iron curb boxes with locking type cover as indicated.

2.7 MOVEMENT DETECTION INSTRUMENTATION - LIQUID TUBE SETTLEMENT SYSTEMS

A. Level Monitoring Devices: Provide liquid settlement system to measure elevation changes between two points, one on a building column or wall and the other at a fixed point outside the building. The points shall be connected by flexible liquid column tubing with T-fitting at each column with the branch tube clamped or attached to the column with a scale marking the liquid level. Use clear plastic and brass fittings.

B. Manometer Settlement Platforms: Provide manometer settlement platforms to measure settlement of embankments and subsurface soils. Manometer settlement platforms to include

tubing, measurement equipment, gauge boxes, protective covers, sand backfill materials and accessories necessary to construct and monitor settlement.

2.8 MOVEMENT DETECTION INSTRUMENTATION - VIBRATING WIRE SETTLEMENT SYSTEMS

A. Provide VW settlement systems to measure subsurface settlement. The VW settlement systems Model 4650 manufactured by Geokon, or Slope Indicator Model 52612099, or approved equivalent, may be used.

2.9 MOVEMENT DETECTION INSTRUMENTATION - TILTMETERS

A. Provide tiltmeter sensors, read out indicators, and tiltmeter base plates.

B. Provide grout or epoxy resin as approved by the Contractor’s geotechnical engineer.

C. Furnish tiltmeter sensors and read-out indicators in numbers sufficient to ensure the constant availability of functioning units on the site in case of loss or failure of the prime units.

2.10 MOVEMENT DETECTION INSTRUMENTATION – CRACK GAUGES

A. Crack gauges include mechanical, grid, and electrical types to monitor horizontal or vertical movement across cracks in concrete, structures, walls, and buildings.

B. Mechanical Crack Gauges:

1. Provide pins for mounting on each side of a discontinuity.
2. Provide appropriate measurement devices including steel tape, steel ruler, or calipers.

C. Grid Crack Gauges:

1. Provide grid crack gauges specifically manufactured for the purpose. Crack gauges shall be capable of monitoring offsets to plus or minus 0.01 inch.
2. Provide screws or adhesives to fix gauges to monitoring surfaces.

D. Electrical Crack Gauges:

1. Electrical crack gauges shall include VW transducers.
2. Provide VW transducers, Geokon, Inc. Model 4420, Roctest Model JM-S, Slope Indicator Model 52636099, or approved equivalent. Range shall be 2 inches.
3. Anchors shall be chosen to fit the surface being monitored.
4. Cables and terminal panels shall be from the same manufacturer as the crack gauges.
5. Portable readout units shall be as recommended by the manufacturer.

2.11 INTERNAL BRACING AND ANCHOR LOAD INSTRUMENTATION

A. Strain Gauges

1. Provide strain gauges that are weather-resistant, suitable for either permanent encasement in concrete, or installation on bracing, or installation on tunneling steel ribs, VW type, Model VSM-4000 as manufactured by Geokon, Inc., or similar by Roctest, Inc., Slope

Indicator Co., or approved equivalent. Furnish latest model developed specifically for applications anticipated within this Contract.

2. Characteristics:
   a. Gauges shall be insensitive to traffic and anticipated construction activity vibrations and able to function underwater.
   b. Gauges shall be capable of attaining a minimum service life of four years.
   c. Gauges shall be complete with mounting brackets, waterproof cable, cable connectors, terminal boxes, protective steel channel covers, and steel flex conduit for full-length protection of cables.

3. Provide terminal boxes recommended by the manufacturer of the strain gages containing switching arrangement which will enable each gauge contained in a load instrumentation zone to be recorded without changing connecting electrical leads.
4. Provide connector wires as recommended by strain gauge manufacturer.
5. Provide VW indicators in quantities sufficient to ensure the constant availability of functioning units on the site in case of loss or failure of prime units.
6. Provide VW read-out box GK-403 VW manufactured by Geokon, Inc., or similar by Slope Indicator Co., or approved equivalent. Furnish in numbers sufficient to ensure the constant availability of functioning units on the site in case of loss or failure of prime units.

B. Load Cells:

1. Provide load cells of bonded strain gauge transducer type, moisture-resistant model developed specifically for load measurements and conditions anticipated within this Contract, Model 51301050 or Model 51301100 electronic load cells manufactured by Slope Indicator Co., Model 3000 manufactured by Geokon, Inc., or approved equivalent. Provide load cells having a working capacity equal to at least yield load of structural member and having accuracy to within one percent of the load range.
2. Provide Model GK-501 readout unit manufactured by Geokon, Inc., Model 51300900 LCD readout unit manufactured by Slope Indicator Co., or approved equivalent compatible with load cells. Terminal boxes shall contain adequate switching arrangements to enable each load cell contained in a load instrumentation zone to be recorded without changing connecting electrical leads.
3. Provide connector wires as recommended by load cell manufacturer.
4. Furnish read-out boxes in numbers sufficient to ensure constant availability of functioning units on the site in case of loss or failure of the prime units.

2.12 GROUNDWATER MONITORING DEVICES

A. Observation Wells:

1. Provide standpipe observation wells consisting Schedule 40 plastic pipes, minimum 2-inch diameter in accordance with ASTM D1785, with a slotted end section that can be isolated at the appropriate level. Access to the top of the observation well shall be provided. The observation well top shall be protected against vandalism.
2. Provide filter material consisting of sand, graded between No. 30 sieve and No. 8 sieve size, clean, washed, and free from extraneous materials, referred to as Monterey No. 2/12 sand, or as dictated by subsurface ground conditions, or approved equivalent.
3. Provide low-shear-strength (10 to 20 psi) lean concrete with or without bentonite for backfill grout.

B. Piezometers: Provide VW piezometers, and related cables and terminal boxes.

2.13 GROUT MIX

A. Provide grout mixtures for inclinometer casings and extensometers in accordance with the manufacturers recommendations.

2.14 TRAFFIC COVERS

A. Provide a cast iron unit with a fastening bolt, lift sockets, and body extension, with minimum 8 inches inside diameter manufactured by Brooks Products, Inc., El Monte, CA, or similar by Morrison Bros. Co., Dubuque, IA, or approved equivalent.

PART 3 - EXECUTION

3.1 GENERAL

A. Notify the Contracting Officer not less than 48 hours before installing any instrumentation.

B. Calibrate instruments per manufacturer's requirements.

C. Notify the Contracting Officer, take corrective measures, and modify construction procedures immediately to prevent any damage to structures, facilities, and utilities, if the geotechnical instrumentation measurements of deformation or ground water levels exceed acceptable limits indicated.

D. Refer to Section 33 05 25, Support and Protection of Utilities. Mark boring locations on the ground surface prior to actual drilling. Have the existing utilities, if any, located as specified in Section 33 05 25, Support and Protection of Utilities, at least three working days before start of drilling. Relocate borings, if necessary, to avoid subsurface utilities.

E. Location of Underground Facilities and Structures:

1. If proposed boring location is within 24 inches of marked utility, expose that facility by hand excavation prior to drilling.
2. Contractor shall verify locations of underground facilities and structures. Locations, where shown for utility facilities, are approximate.

F. Disclosure of Instrumental Data: Do not disclose instrumentation monitoring data to third parties, and do not publish instrument monitoring data without the prior written permission of the Contracting Officer.

3.2 MOVEMENT DETECTION INSTRUMENTS - INCLINOMETER CASINGS INSTALLATION

A. Drill minimum 6-inch-diameter and maximum 8-inch-diameter holes, at locations indicated, to required depths to receive inclinometer casing.

B. Use qualified personnel to witness and log samples during drilling and to prepare logs of soil and rock encountered. Make soil classifications and preparations in accordance with ASTM D2487, D2488, and D5434.

1. In soil obtain samples in accordance with ASTM D1586 with Standard Split Spoon or equivalent;
   a. Sample at minimum 5-foot intervals and at each change in stratification.
   b. In rock, log continuous NX or AX cores, as applicable, to the specified installation.

2. Submit the logs and samples.

C. Drill to a depth of not less than 15 feet below final bottom of excavation, or as required, and install casings. Install in conformance with the inclinometer casing manufacturer's installation instructions. Install one grooved axis of casing perpendicular to nearest excavation wall, slope, or feature of interest. Install casing within 2 degrees of vertical and demonstrate by means of a torque rod or other approved method that no more than 10 degrees of twist or differential axial rotation exists between the top and bottom of casing.

D. Cap bottom of casings and fill annular space between casings and sides of holes with inclinometer casing grout pumped through a pipe or small tube to bottom of hole.

E. Ground Surface Protection:

1. If inclinometer casings will be within unpaved work areas, project tops of inclinometer casings a minimum of 16 inches above the ground. Protect inclinometer casings with 8-inch diameter steel (ASTM A36/A36) casings. Locate tops of inclinometer casings not further than 2 inches below tops of steel casings. Embed steel casings 4 feet into ground, project 18 inches above ground elevation, and provide with removable caps. Mark steel casings with yellow paint.
2. If inclinometer casings will be in paved areas, excavate a hole 2 feet deep by maximum 12 inches in diameter, through paving, and install a valve box. Make the box flush with the paved surface and fill annular space between the box and the hole walls with concrete. Project inclinometer casings within 3 inches of surface and not less than 2 inches above bottom of excavated ground surface within valve box or as required to read instrument. Close hole through pavement with a removable cover.

F. Maintain inclinometer casings in operating condition from time of installation until completion of work requiring inclinometer casings. Keep inclinometer casings locked when not being read or serviced. Establish and maintain convenient access.

3.3 MOVEMENT DETECTION INSTRUMENTS - BOREHOLE EXTENSOMETER INSTALLATION

A. Drill boreholes of size and at locations indicated to required depth and to receive borehole extensometer.

B. Use qualified personnel to observe and log samples during drilling and to prepare logs of soil and rock encountered. Make soil and rock classifications and preparations in accordance with ASTM D2487, D2488, and D5434.

1. In soil, obtain samples in accordance with ASTM D1586 with Standard Split Spoon or equivalent.
2. Sample at minimum 5-foot intervals and at each change in stratification.
3. In rock, log continuous NX or AX cores, as applicable, to the specified installation.

C. Submit the logs and samples.

D. Verify hole is drilled such that manufacturer's installation requirements will be met.

E. Install multiple-anchor rod-type extensometers at locations indicated.

F. Tremie sand-cement grout from the bottom of the hole.

3.4 MOVEMENT DETECTION INSTRUMENTS - TAPE EXTENSOMETER

A. Install tape extensometer anchor points on excavation walls or tunnel rings as soon as the plan locations of anchor points indicated are exposed.

1. If tunnel equipment or operations prevent the installation of anchor points or taking readings, use alternate methods as approved by the Contractor's geotechnical engineer and accepted by the Contracting Officer.
2. Install tape extensometer standard on tunnel sidewall in an area free from disturbance by equipment and freely accessible for use.

B. Maintain anchor points in functional condition and remove obstructions from lines of measurement, as necessary, for monitoring.

3.5 MOVEMENT DETECTION INSTRUMENTS - DEEP BENCHMARK INSTALLATION

A. Establish a system of benchmarks as indicated before starting excavation and before other instruments are installed.

B. Drill minimum 4 1/2-inch-diameter and maximum 8-inch-diameter holes, to 10 feet in soil or 3 feet in rock, below bottom of future excavation or the tunnel construction invert. Install the outer casings to the bottom of the hole. Install steel spiders to center the 2-inch-diameter inner casings, at a maximum spacing of 20 feet.

1. In soil, split the inner casings for 12 inches at tips, as indicated, and drive the inner casings 2 feet into undisturbed soil below bottom of outer casings.
2. In rock, drill the inner casings 2 feet into rock below bottom of outer casings and grout bottom 12 inches of inner casings in place.
3. Pump heavy grease into annular space between the 2-inch-diameter and the 4-inch-diameter steel pipes until the space is completely filled.

C. Weld stainless steel read point to top end of benchmark pipe.

3.6 MOVEMENT DETECTION INSTRUMENTS - SHALLOW SUBSURFACE SETTLEMENT REFERENCE POINT INSTALLATION

A. Shallow Subsurface Reference Points:

1. Establish a system of settlement reference points on or about buildings and structures, as indicated, before starting excavating and dewatering, or other construction activities. Correlate system with benchmarks established as reference points.
2. Locate and construct reference points in a manner which will not create a hazard to pedestrians and vehicles. Maintain access to settlement reference points.
3. Drive pipe to required depth utilizing a coupling and nipple as a striking surface.

4. Adjust depth-to-site conditions to embed pipe in soil below pavement.
5. Remove coupling and nipple and install pipe cap with read point.
6. Excavate around pipe and place curb lock box. Backfill outside of box. Leave box with the cover locked.

B. Ground Surface Settlement Points:

1. Establish reference points on and about building and structures, as indicated. Locate and construct reference points in a manner which will not create a hazard to pedestrians and vehicles. Maintain access to reference points.
2. For buildings or structures within zone of influence of the proposed excavation boundaries, install reference points on the outside of the building at a convenient height above grade, on all corners, and at each column, or on walls, at spacings not to exceed 20 feet. Insofar as practicable, install all points on each side of the building at the same elevation. Install before installation of the excavation support systems and underpinning, and before beginning of dewatering operation.

3.7 MOVEMENT DETECTION INSTRUMENTS - BUILDING SETTLEMENT REFERENCE POINT INSTALLATION

A. Install building settlement reference point where shown on approved shop drawings.

B. Drill correct diameter and depth hole into receiving surface.

C. Blow out drilling debris from the hole.

D. Assemble expansion anchor and insert into hole.

E. Tap outer sleeve onto wedge nut to affect initial sleeve contact with wall of hole.

F. Expand outer sleeve into tight contact with wall of hole by turning bolt until anchor is rigid with the hole. Do not strip wedge nut threads by excessive turning of the bolt

3.8 MOVEMENT DETECTION INSTRUMENTS - DEEP SUBSURFACE SETTLEMENT INDICATOR INSTALLATION

A. Install each deep subsurface settlement indicator as indicated.

B. Drill holes for the outer casings to a point 2 feet above the required tip elevation of the inner pipe. Do not damage the casing or disturb the soil below the casing where the inner pipe will be anchored.

C. Install outer casing and grout in place.

D. Install protective cast iron curb boxes (ASTM A48/A48) and grout in place.

E. Install inner pipe split 12 inches at tips by driving to required elevation. Where inner pipe is to rest on a subsurface structure, take care not to damage or penetrate more than necessary for attachment to the subsurface structure. Pump heavy grease into annular space between outer casing and inner pipe until space is completely filled.

F. Set pipe cap reference surface.

G. Install cover and lock.

3.9 MOVEMENT DETECTION INSTRUMENTS - LIQUID TUBE SETTLEMENT SYSTEMS

A. Level Device Installation:

1. Install level device where shown on approved shop drawings.
2. Install plastic tubing filled with liquid around the lower level of the structure with a T-fitting at each column and the branch tube clamped to the column with a scale marking the liquid level.
3. Change in the liquid level on the scale will be indicative of the column settlement.
4. Record change in liquid level reading at each column.
5. Protect tubes from damage during the Work.

B. Manometer Settlement Platforms

1. Install manometer settlement platforms and related settlement measuring equipment at locations shown on the approved shop drawings under the observation of the Contractor's geotechnical engineer.
2. Place settlement platforms, tubing, and other appurtenant measurement equipment before the placement of any embankment or other fill.
3. Perform trench work for the placement of plastic tubing during installation of the settlement platforms. The Contractor shall excavate and backfill trenches as required by the Contractor's geotechnical engineer. Consider this item a first order of work during construction of embankments.
    a. Place trench backfill in two layers: 6 inches for bedding below the plastic tubing and 6 inches for cover of plastic tubing.
    b. Fill remainder of trench with excavated material. Do not place fill material containing rock exceeding 4 inches in diameter over the system.
    c. Obtain the Contractor's geotechnical engineer's approval of trench bedding and backfill materials prior to placement.

4. Cover the measurement systems with backfill as soon as they have been installed. Do not run heavy equipment, including heavy rolling and vibrating compactors, in the area immediately above the platforms and plastic tubing until fill has been placed to an elevation of at least 3 feet above the top of the system. Compact the fill without damage or disturbance to the system.
5. Install a gauge and box required to read the settlement platforms. Locate gauge or box a minimum of 15 feet outside of planned embankment limits unless right-of-way (ROW) or other obstructions prevent the 15-foot minimum clearance. The gauge boxes shall be surveyed weekly by the Contractor in order to evaluate movement of the gauge box.

3.10 MOVEMENT DETECTION INSTRUMENTS - VIBRATING WIRE SETTLEMENT SYSTEMS

A. Install VW settlement systems at the locations shown according to the manufacturer's specifications and take initial readings prior to placement of any fill.

B. Install a terminal box required to read the VW settlement systems. Locate terminal box a minimum of 15 feet outside of planned embankment limits unless ROW or other obstructions

prevent the 15-foot minimum clearance. The terminal boxes shall be surveyed weekly by the Contractor in order to evaluate movement of the terminal box.

3.11 MOVEMENT DETECTION INSTRUMENTS - TILTMETER INSTALLATION

A. Install tiltmeter where shown on approved shop drawings.

B. Bond tiltplates on buildings and structures with grout or epoxy resin, as specified, before starting excavating and dewatering.

C. Maintain access to tiltplates.

D. Remove and dispose of the tiltplates upon completion of the Contract. Restore disturbed or damaged surfaces to the conditions existing prior to installation of tiltplates.

3.12 MOVEMENT DETECTION INSTRUMENTS – CRACK GAUGES

A. Install mechanical, grid, and/or electrical crack gauges where shown on approved shop drawings.

B. Install crack gauges in accordance with manufacturer's recommendations.

C. Maintain access to crack gauges.

3.13 INTERNAL BRACING AND ANCHOR LOAD INSTRUMENTATION SYSTEMS INSTALLATION

A. A load instrumentation zone is defined as containing:

1. Strain gauges, switch boxes, connection wires, and other auxiliary hardware installed on or for cross bracing struts, at all strut levels, in three consecutive strut lines at the zone locations in plan, as indicated
2. Load cells, switch boxes, connecting wire, and other auxiliary hardware installed on or for tiebacks on both sides of the excavation within the plan limits as shown

B. Strain Gauges:

1. Install strain gauges in sets on bracing members at the end opposite the one being jacked. Exact locations be determined by the Contractor's geotechnical engineer to suit the design of the bracing system. Install strain gauges before preloading bracing members, in conformance with the strain gauge manufacturer's installation instructions. Install the first 20 stain gauges under the supervision of a qualified representative of the strain gauge manufacturer.
2. For each zone of strain gauges on stressed bracing members, install one additional temperature compensation strain gauge on an unstressed segment of strut affixed to the support wall in a position to be subject to the same temperature fluctuations as the stressed member. Install the temperature compensation gauges in the same manner as those installed on stressed members.
3. Connect strain gauges to terminal boxes in conformance with the strain gauge manufacturer's instructions. Route wiring to prevent mechanical damage and encase in steel or PVC conduit. Connect and operate the first load instrumentation zone under the supervision of a qualified field representative of the strain gauge manufacturer.

4. Install terminal boxes for each load instrumentation zone at street level within 10 feet of the excavation, in a protected location.
5. Assign alphanumeric designations to the strain gauges that are consistent with the Contractor's chosen designations for the support ribs. Clearly label electrical leads.

C. Load Cells:

1. Install load cells between walers or soldier piles and earth anchor plates. Exact locations will be determined in accordance with the approved shop drawings. Install load cells in conformance with the load cell manufacturer's instructions.
2. Connect load cells to terminal boxes in conformance with the load cell manufacturer's instructions. Encase connections in waterproof conduit. Connect and operate under the supervision of a qualified field representative of load cell manufacturer for the first load instrumentation zone.
3. Install terminal boxes on both sides of each load instrumentation zone, at street level within 10 feet of excavation, in a protected location.
4. Assign alphanumeric designations to the load cells that are consistent with the Contractor's chosen designations for the support ribs. Clearly label electrical leads.

3.14 GROUNDWATER MONITORING DEVICES INSTALLATION

A. Observation Wells:

1. Install observation wells and make them functional at least two weeks before beginning dewatering operations or commencement of any excavation within 250 feet, whichever occurs first. In the presence of the Contractor's geotechnical engineer, prove proper functioning of the observation wells upon installation and demonstrate that each well is functioning properly by measuring rate of rise or fall of water levels therein.
2. Drill holes for observation wells to the indicated diameters and to the indicated depths. If necessary to prevent caving, case holes with a temporary flush joint type casing. As an alternative method, drilling fluid of a self-destroying type, which loses its viscosity after a period of time, may be used. After reaching the required depth, clean the hole of loose earth, particles of cuttings, and other debris.
3. Use qualified personnel to observe and log samples during drilling and to prepare logs of soil and rock encountered. Make soil and rock classifications and preparations in accordance with ASTM D2487, D2488, and D5434.
   a. In soil, obtain samples in accordance with ASTM D1586 with Standard Split Spoon, or equivalent.
   b. Sample at minimum 5-foot intervals and at each change in stratification.
   c. In rock, log continuous NX or AX cores, as applicable, to the specified installation.

4. Set the bottom of the slotted pipe to the elevation indicated. Flush self-destroying drilling fluid, if used, out of the hole. Place filter material in the hole to surround the pipe up to the elevation of the seal. For observation wells, seal the annulus around the riser pipe with a 3-foot-thick plug of bentonite pellets and then another 2 feet of low-shear-strength (10 to 20 psi) lean concrete/bentonite mixture. Backfill the remainder of the hole with sand or grout. Withdraw temporary casing, if used, as the filter material and backfill are placed.
5. Remove temporary casing. Install permanent casing before the top 10 feet of drilled hole is filled. Install the cover and secure it to the permanent casing.

6. Jet observation well to its full depth with a small-diameter pipe or hose, as required for cleaning.
7. Unless indicated for removal, maintain observation wells. Keep the wells in good condition until the completion of work or turnover to the Contracting Officer.
8. While dewatering system is operating, prove continued proper functioning of each observation well by measuring rate of rise and fall of head tests on a weekly schedule or more frequently.
9. Take an initial set of reference water level readings after installation and at least 24 hours before dewatering to evaluate prevailing initial groundwater conditions.

B. Piezometers:

1. Install VW piezometers and make functional at least 30 days before the start of dewatering, or before the start of tunneling, or before excavating within 100 feet.
2. The VW piezometers shall be installed in accordance with the manufacturer’s recommendations and at the locations and depths necessary to monitor groundwater drawdown and the effect of other dewatering systems that may be in use on the area being monitored.
3. Use qualified personnel to observe and log samples during drilling and to prepare logs of soil and rock encountered. Make soil classifications and preparations in accordance with ASTM D2487, D2488, and D5434.
   a. In soil, obtain samples in accordance with ASTM D1586 with Standard Split Spoon or equivalent.
   b. Sample at minimum 5-foot intervals and at each change in stratification.
   c. In rock, log continuous NX or AX cores, as applicable, to the specified installation.

4. Prior to insertion of the piezometer in the borehole, a reading shall be taken of the vibrating wire transducer, thermistor, and corresponding barometric pressure.
5. After insertion of the piezometer, a check shall be made to ensure that the piezometer reading agrees with the water head, and the elevation of the diaphragm shall be recorded.
6. After completion of installation, a post-installation acceptance test shall be performed to verify that the piezometer functions correctly.

3.15 TRAFFIC COVERS

A. Excavate a hole 2 feet deep through the paving and install the traffic cover. Make the cover flush with the paved surface and fill the annular space between the traffic cover body and the hole with lean concrete. Project casings within 3 inches of surface and not closer than 2 inches above ground surface within valve box, or as required to read the instrument. Close hole through pavement with a removable cover.

3.16 MONITORING SCHEDULE

A. General:

1. At a minimum, perform monitoring of geotechnical instrumentation and follow the minimum schedule as specified below.
2. When instrumentation detects sudden changing movement, loads, or groundwater levels, take additional reading in number and frequency as required by the Contractor’s geotechnical engineer.

B. Fills, Embankments, Slopes, Walls, and Structures Monitoring:

1. Instruments to monitor fills, embankments, slopes, walls, and structures may include inclinometers, VW settlement systems, manometer platforms, settlement reference points and other instrumentation.
2. For inclinometers to monitor fills and embankment, two initial inclinometer readings shall be taken prior to placing fill material. After the initial inclinometer readings are completed and fill placement has begun, inclinometer readings shall be taken at the completion of each fill lift. Inclinometer readings will be taken at least once per week for at least three weeks after fill, including surcharge, and placement has been completed. In addition, inclinometer readings will be taken at any other time deemed necessary.
3. At a minimum, all instruments shall be monitored on a weekly basis during fill placement and/or construction of walls, structures, or slopes. The monitoring will continue on a weekly basis until the frequency can be reduced or increased based on the weekly readings and engineering judgment.

C. Open-Cut and Cut-and-Cover Excavation Monitoring:

1. Movement detection instruments, within 50 feet of the excavation: Monitor an average of once per day during excavation and once per week thereafter.
2. Movement detection instruments 50 feet or more outside of the excavation: Monitor an average of once every other day during excavation and once every other week thereafter.
3. Internal bracing and anchor load instrumentation: Monitor an average of once per day while excavating 50 feet on either side of strut location and once every week thereafter until the internal bracings are removed, as applicable, or the structure is complete to a point where the tiebacks are no longer needed for excavation support.

D. Tunnel Excavation Monitoring:

1. For the purposes of monitoring, instruments considered to be affected during construction of each individual tunnel are within a zone bounded by planes at a slope of 1H:1V (Horizontal:Vertical) at right angles to the tunnel alignment and tangent to the tunnel periphery.
2. Provide the instrumentation and take three readings of each instrument to establish an initial value. Take each of the three initial readings at an interval of at least 24 hours. Take the third and the last initial reading at least two weeks prior to the tunnel face approaching within 100 feet of the instrument. If the initial readings show a large variance, take additional readings to re-establish the initial reading.
3. Read movement detection instruments including borehole extensometers within the affected zone as defined below and within 100 feet either side of the tunnel face, the more frequent of the following: from 50 feet to 10 feet before and from 20 feet to 50 feet after the tunnel face, each tunneling shift or daily; from 10 feet before to 20 feet after the tunnel face, every four hours or ten feet of tunnel advance; and more than 50 feet after the tunnel face, at least weekly for one month.
4. Except for tape extensometer, read movement detection instruments once per shift while within the affected tunneling within 100 feet either way of the tunnel face, as follows:
   a. Once per shift or once per day, whichever is more frequent while tunneling within the 100 feet distance
   b. At least once per day for one week after the tunnel excavation has passed the 100-foot limit and once every week for one month thereafter

5. Read movement detection instruments installed outside the affected zone once before the start of tunnel excavations at least once per day during tunneling when the tunnel is within 100 feet either way of the instrumentation stationing, and once per week for one month thereafter.
6. Read level monitoring devices installed inside buildings near the proposed tunnel route for monitoring settlements on a schedule that is coordinated with ground improvements as required and as follows:
    a. At least once per day during tunneling when the tunnel is within 100 feet of the building
    b. At the end of each shift while tunneling under or near each affected building column
    c. Then once per day for one week
    d. Then once every week for one month thereafter

E. Observation Wells and Piezometers:

1. Groundwater monitoring requirements depend on the level of the groundwater at the site during construction.
2. Record the elevation of the water level once per day as long as dewatering systems are in operation.
3. If the groundwater level is below the bottom of the excavation and if no dewatering is required or performed, then the water level shall be recorded once a week during the excavation.
4. Maintain the observation wells and piezometers in good condition by sounding and reading at least monthly, on a regular basis, and repairing or replacing, as necessary, until the completion of the Work.

F. Monitor instrumentation more frequently if instrumentation detects significant, anomalous, or suddenly changing deformations, loads, or hydrostatic pressures.

3.17 INSTRUMENT PROTECTION, MAINTENANCE, AND REPLACEMENT

A. Protect and maintain instruments. Drain water or flush debris from under protective covers. Keep protective covers locked.

B. Provide suitable substantial protective barriers around instruments in construction areas.

C. Repair or replace damaged or missing instrument components or entire instruments, as required, within 48 hours at no extra cost to the Authority.

D. Perform no work within 100 feet of a damaged instrument until it has been repaired to operation condition.

3.18 REMOVAL OF INSTRUMENTS

A. Prior to the final acceptance of the Work, request and obtain written agreement from the Contracting Officer for the removal of instruments. Remove and dispose of instrumentation and restore locations where it was located. Comply with the following requirements:

1. Remove and dispose of the settlement reference points together with the protective boxes and covers. Fill holes drilled in masonry or concrete surfaces for settlement reference points with Portland cement mortar.
2. Demolish inclinometer casings, unless otherwise required, to a minimum depth of 2 feet below ground surface. Plug remaining open portions of inclinometer casings with Portland cement concrete. Backfill casing excavations with suitable material. In paved areas, construct aggregate base and new pavement patch using same materials and to the same thickness as existing adjacent pavement. Restore disturbed or damaged surfaces to the conditions existing prior to installation of instruments.
3. Remove and dispose of crack gauges.
4. Remove painted instrument identification numbers from building and other surfaces. Remove wooden markers and protective barriers.
5. Restore building and other surfaces to the condition existing prior to installation of instrumentation and to match surrounding finishes and surface.
6. Restore and replace insulation, protective wrappings, and covers on utilities.
7. Backfill excavations made over and around utilities.
8. Fill observation wells in accordance with the requirements of the jurisdictional authority.

B. If required by the Contracting Officer, maintain instrumentation until final acceptance and leave it in place at the completion of the Work for use by the Authority and follow-on contractors.

C. When the following instrumentation and appurtenances are required to remain in place, they shall be subject to the following requirements:

1. Upon completion of the Contract, leave cased deep benchmarks in place. Set cased deep benchmark protective covers flush with pavement or surrounding ground.
2. Terminate monitoring of observation wells and piezometers when permitted by the Contracting Officer. Leave observation wells in place, and set observation well covers flush with pavement or surrounding ground.

3.19 CONTRACTING OFFICER'S MONITORING

A. Access to Instruments: Provide and facilitate safe access to each instrument for the Contracting Officer at all times. Access includes ladders, working platforms, and other necessary facilities, and the removal thereof.

B. The Contracting Officer may perform supplemental monitoring of instruments at any time. Cooperate with such instrumentation monitoring activities as follows:

1. Make probes, sensors, and read-out devices available as required.
2. Coordinate activities to minimize interference.
3. Remove obstruction from lines of sight when requested by the Contracting Officer.
4. Regulate traffic during instrument surveying operations.
5. Temporarily cease activities which create hazards to instrument monitoring or surveying personnel.

END OF SECTION

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SECTION 31 11 00

CLEARING AND GRUBBING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Clearing and grubbing.

B. Tree branches.

C. Demolition/removal.

D. Disposal of removed materials and debris.

E. Salvage.

F. Backfill.

1.2 RELATED SECTIONS

A. Care of existing trees and plants is specified in Section 02 01 56.39, Temporary Tree and Plant Protection.

B. Demolition of structures and removal, salvage, or other disposition of slabs, footings and foundations; existing pavement, curbs and gutters, sidewalks, headwalls, walls, and steps; utility service facilities; guardrail and posts, highway and street signs and fences; and other miscellaneous structures and site improvements that interfere with new construction are specified in Section 02 41 00, Demolition.

C. Removal of items that are buried below grade is specified in Section 31 05 00, Common Work Results for Earthwork.

D. Protection of utilities is specified in Section 33 05 25, Support and Protection of Utilities.

1.3 REFERENCE STANDARDS

A. American National Standards Institute (ANSI)

1. ANSI A300, Part 1 Tree Care Operations - Tree, Shrub and Other Woody Plant Maintenance - Standard Practices, (Pruning).

2. ANSI Z 133.1 Safety Requirements for Pruning, Trimming, Repairing, Maintaining And Removing Trees, and For Cutting Brush.

1.4 SUBMITTALS

A. Utility Severance Certificates: Provide certificates of severance of utility services, issued by the utility owners, for review and record purposes.

1.5 REGULATORY REQUIREMENTS

A. Regulatory requirements that govern the work of this Section include the following governing codes :

1. California Code of Regulations, Title 8, Chapter 4, Subchapter 4 — Construction Safety Orders
2. California Code of Regulations, Title 24, Part 2, California Building Code, Chapter 33, Protection of Pedestrians During Construction or Demolition

1.6 QUALITY ASSURANCE

A. Qualified arborist shall be either an International Society of Arboriculture (ISA) Certified Arborist or an American Society of Consulting Arborists (ASCA) Registered Consulting Arborist and possess a minimum of five years of experience in supervising or perform tree pruning specified herein.

1.7 JOBSITE CONDITIONS

A. Dispose of cleared, grubbed, and removed material away from the site. Burying and burning of materials at the site will not be permitted. Stockpile salvaged material in a secured location.

B. Clear and restore areas used for the Contractor's convenience. Restore such areas to their original condition, and provide mulching, seeding, and planting as required.

C. Protect survey markers and monuments, existing improvements, and adjacent properties from removal and damage.

D. Give written notices to utility companies and municipal departments requesting discontinuance of services to areas that will be affected by the site clearing and grubbing work.

1.8 CARE OF EXISTING TREES

A. Trees and plants indicated to remain and to be preserved shall be protected. Refer to Section 02 01 56.39, Temporary Tree and Plant Protection.

B. Use no weed-eaters or edgers within 15 inches of any tree designated to remain; perform weed or other trimming by hand within this 15 inches.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. The Contractor shall furnish all materials, tools, equipment, facilities, and services as required for performing site clearing, grubbing and other site preparation work.

PART 3 - EXECUTION

3.1 CLEARING AND GRUBBING

A. Perform clearing and grubbing as necessary to remove vegetation and objectionable material from the site. Clear the site as indicated on the Construction Drawings and remove cleared materials and debris from the site. Unless otherwise indicated, clearing and grubbing shall include removing the top 4 inches of the existing ground. Coordinate with salvaging of topsoil specified in Section 31 05 00, Common Work Results for Earthwork.

B. Remove stumps and roots completely in excavation areas and under embankments where the original ground level is within 3.5 feet of sub grade or slope of embankments. In embankment areas under trackway, completely remove stumps and roots. In other embankment areas, where the original ground level is more than 3.5 feet below the sub grade or slope of embankment, cut off trees, stumps, and brush to within 6 inches of the ground.

C. Do not start earthwork operations in areas where clearing and grubbing are not complete, except that stumps and large roots may be removed concurrently with excavation.

D. Where the work includes requirements for wood chip mulch, acceptable material from clearing and grubbing activities may be used to produce such mulch.

E. Refer to Section 02 01 56.39, Temporary Tree and Plant Protection, for tree disease protection requirements.

3.2 TREE BRANCHES

A. Pruning shall be performed under the supervision of a qualified arborist.

B. Perform pruning in accordance with ANSI A300 and ANSI Z133.1. Pruning shall be carried out by experienced pruning personnel. Sterilize pruning tools between tools' use on individual plants. Remove tree branches overhanging roadways and other designated areas of the site to within 20 feet of finish grade. Remove tree branches overhanging trackways of other railroads to within 20 feet of finish grade or greater as required by the jurisdictional authority. At high-speed trackway and other electrified trackways, remove tree branches from within 20 feet of nearest rail and with 10 feet of line of OCS poles both measured horizontally. Cut off branches neatly and close to the tree boles. Remove other branches as necessary to present a balanced appearance.

C. Workmen shall not be permitted to climb trees to be pruned with climbing spurs, but they shall comply with the requirements of good practice and safety in the use of safety ropes.

D. Existing injuries to bark, trunks, and limbs, as designated by the Contractor's landscape architect, shall be repaired by properly cutting, smoothing the wood if necessary, tracing the bark to the proper shape to ensure rapid healing, using only approved tools and materials.

E. When pruning has been completed, the area shall be cleaned up.

3.3 DEMOLITION/REMOVAL

A. Coordinate the work of this Section with the work of Section 02 41 00, Demolition, as required to remove existing pavements, curbs, structures, foundations, and site improvements that interfere with new construction and where demolition is not indicated.

B. Remove walls, masonry construction, and slabs to a minimum depth of 2 feet below existing ground level in areas where such items do not interfere with new construction; otherwise complete removal is required. Slabs shall be broken for drainage when left in place under the provisions of this Article.

C. Take possession of, remove, and dispose of abandoned rail and track materials.

3.4 DISPOSAL OF REMOVED MATERIALS AND DEBRIS

A. Dispose of removed materials, waste, trash, and debris in a safe, acceptable manner, in accordance with applicable laws and ordinances and as prescribed by jurisdictional authorities. Refer to the General Provisions for construction waste management and disposal requirements, including recycling requirements.

B. Burying or burning of trash and debris on the site will not be permitted.

C. Remove trash and debris from the site at frequent intervals so that its presence will not delay the progress of the Work or cause hazardous conditions for workers and the public.

D. Removed materials, waste, trash, and debris shall become the property of the Contractor and shall be removed from the site and disposed of in a legal manner. Location of disposal site and length of haul shall be the Contractor's responsibility.

3.5 SALVAGE

A. Refer to Section 02 41 00, Demolition, for salvage requirements.

3.6 BACKFILL

A. Backfill trenches and excavations resulting from work under this Section in accordance with applicable requirements of Section 31 05 00, Common Work Results for Earthwork.

END OF SECTION

SECTION 31 23 19

DEWATERING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Dewatering

B. Records

C. Restoration

1.2 RELATED SECTIONS

A. Coordinate the work of this Section with the work of Section 02 22 00, Existing Conditions Assessment, Section 31 50 13, Temporary Excavation Support and Protection, and Section 31 09 13, Geotechnical Instrumentation and Monitoring.

1.3 DESCRIPTION

A. Dispose of pumped water, and construct, maintain, observe, and remove equipment when no longer needed.

B. Control and disposal of storm water runoff; lowering the water table and intercepting seepage which would otherwise emerge from the slopes or bottoms of excavations; increasing the stability of excavated slopes; preventing loss of material from beneath the slopes or bottoms of excavations; reducing lateral loads on sheeting and bracing; improving the excavating and hauling characteristics of sandy soil; preventing rupture or heaving of the bottom of an excavation; and protection and restoration of adjacent structures, including repair of settlement-related damage.

1.4 PERMITS

A. The Contractor shall obtain, from jurisdictional authorities, all permits and licensing for dewatering and disposal of pumped water as required to construct and complete the Work.

B. Comply with EPA requirements.

1.5 SUBMITTALS

A. Submit pre-construction surveys, as specified in Article entitled “Site Conditions” herein.

B. Submit procedures for detection of movement and records of movement detection, as specified in Article entitled “Detection of Movement”.

C. Prior to installation of the dewatering system, submit Shop Drawings and design data, indicating the following:

1. The proposed type of dewatering system;

2. Arrangement, location, and depths of system components;
3. Complete description of equipment and instrumentation to be used, with installation, operation, and maintenance procedures;
4. Types and sizes of filters;
5. Design calculations demonstrating adequacy of the proposed system and equipment; and
6. Methods of disposal of pumped water.

D. Submit copies of permits required for performing the work of this Section.

E. Submit records of monitoring for movement specified in Article entitled “Detection of Movement” herein.

F. Submit records specified in Article entitled “Records” herein, including observation records and water quality test results.

1.6 REGULATORY REQUIREMENTS

A. Comply with the California Code of Regulations, Title 8, Chapter 4, Subchapter 4 — Construction Safety Orders.

B. Methods of groundwater discharge, conveying, and transmission to off-site locations shall meet with the approval of the jurisdictional authorities. Comply with the regulatory requirements including those for water pollution prevention.

1.7 SITE CONDITIONS

A. Perform pre-construction surveys in accordance with Section 02 22 00, Existing Conditions Assessment, and Section 31 09 13, Geotechnical Instrumentation and Monitoring. These surveys shall include photographs, maps, plans, written descriptions, and surveyed foundation levels as necessary to fully document pre-construction conditions.

B. Surface Drainage: Intercept and divert precipitation and surface water away from excavations through the use of dikes, curb walls, ditches, pipes, sumps, or other means.

C. Drainage of Excavated Areas:

1. Provide and maintain ditches of adequate size to collect surface and seepage water which may enter the excavations. Divert the water into sumps and drain or pump into drainage channels or storm drains or sewers, subject to the approval of jurisdictional authorities.
2. When water is to be diverted into a storm drain, provide settling basins or other approved facilities as required to reduce the amount of fine particles which may be carried into the drain. If a storm drain becomes blocked or its capacity restricted due to dewatering operations, make arrangements with the jurisdictional authority, and clean the drain.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. Furnish all materials, tools, equipment, facilities, and services as required for providing the necessary dewatering work and facilities.

B. Refer to Section 31 09 13, Geotechnical Instrumentation and Monitoring. Provide piezometers for monitoring groundwater levels and other instruments and measuring devices as required.

2.2 DESIGN CRITERIA

A. The Contractor shall perform site-specific field testing to determine soil permeabilities to be used for design of the dewatering system.

B. The Contractor shall be responsible for the design and adequacy of the dewatering system. Design the dewatering systems to perform as follows:

1. Effectively reduce the hydrostatic pressure and lower the groundwater levels below the excavation;
2. Develop a substantially dry and stable subgrade for prosecution of construction operations;
3. Prevent damage to adjacent properties, buildings, structures, utilities, and other work as a result of settlement or other groundwater-related effects; and
4. Ensure no soil particles will be present in the discharge during construction.
5. Wherever possible, groundwater shall be discharged into a nearby, existing storm drainage system.
6. Ensure water quality test results meet the requirements set forth by the jurisdictional authority.
7. Design groundwater level shall be at least two feet below the bottom of excavation.

C. Methods of dewatering may include sump pumping, single or multiple stage well point systems, eductor and ejector type systems, deep wells, and combinations thereof.

D. Locate dewatering facilities where they will not interfere with utilities and construction work to be performed by others.

E. Modify dewatering procedures that cause, or threaten to cause, excessive ground movement or damage to new or existing facilities, so as to prevent further ground movement damage.

PART 3 - EXECUTION

3.1 DETECTION OF MOVEMENT

A. Refer to Section 31 09 13, Geotechnical Instrumentation and Monitoring.

B. For each existing structure that may be affected by the work, install settlement markers on each footing, building corners, wall or surrounding structures to be monitored. Settlement markers shall be capable of being read to an accuracy of 0.005 foot.

C. Take and record readings as per the frequency set forth in Section 31 09 13, Geotechnical Instrumentation and Monitoring during performance of the dewatering work until the permanent structure is complete to the ground level.

D. Stop work; notify the Contracting Officer, and take immediate remedial action if movement of the existing structure occurs during performance of the work.

E. Upon completion of the dewatering work, take weekly readings of the measurement points for a period of 4 weeks, or longer if movement persists, and report the results to the Contractor's geotechnical engineer and copy the results to the Contracting Officer for reference.

F. The detection of movement shall be performed by a qualified licensed civil engineer or land surveyor as per Section 31 09 13 Geotechnical Instrumentation and Monitoring.

3.2 DEWATERING

A. Perform dewatering in accordance with approved shop drawings. Keep the Contractor's geotechnical engineer advised of any changes made to accommodate field conditions and, on completion of the dewatering system installation, ensure the system is depicted on the as-built drawings as necessary to indicate the installed configurations.

B. Organize dewatering operations to lower the groundwater level in excavations as required for prosecution of the work, and to provide a stable, dry subgrade for the prosecution of construction operations. Prior to placement of concrete, the subgrade shall be in a firm, well-drained condition, and of adequate and uniform load-bearing nature to support construction personnel, construction materials, construction equipment, and steel reinforcing mats without tracking, rutting, heaving, or settlement. All weak, soft, saturated, or otherwise unsuitable material shall be removed and replaced with approved backfill.

C. Maintain water level at lower elevations, so that no danger to structures can occur because of buildup of excessive hydrostatic pressure, and provide for maintaining the water level a minimum of 2 feet below the subgrade.

D. Additional temporary lowering of the water table may be required to provide suitable soil conditions for the preparation of subgrades for footings and foundations. This may be accomplished by increased pumping from wells, installation of trench drains and sumps, or other appropriate methods.

E. Maintain groundwater level a minimum of 2 feet below the prevailing level of backfill being placed.

3.3 RECHARGING

A. Recharge the groundwater table in the areas affected by dewatering operations when structures, substructures, utilities, and sidewalks would exceed the estimated settlements as induced by dewatering prior to recharging.

3.4 RECORDS

A. Observe, record, and submit the average flow rate and time of operation of each pump used in the dewatering system, including flow-rate data during the period that the dewatering system is in operation. Where necessary, provide appropriate devices, such as flow meters, for observing the flow rates.

B. Observe and record the elevation of the groundwater during the period that the dewatering system is in operation. Submit observation records within 24 hours of reading, on a regular basis.

C. During initial period of dewatering, make required observations on a daily basis. If, after a period, dewatering operations have stabilized, reduce observations to longer intervals as appropriate.

D. Monitor quality of discharge from dewatering system to determine if soil particles are being removed by the system.

E. Submit water quality test results on a periodic basis as required by the jurisdictional authority.

3.5 RESTORATION

A. Restore existing structures to conditions equivalent to those existing prior to the start of work, including repair of any settlement-related damage.

END OF SECTION

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SECTION 31 23 26

AGGREGATE DRAINAGE LAYER

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Aggregate drainage fill.

B. Vapor retarder.

C. Field quality control.

1.2 RELATED SECTIONS

A. Preparation of sub grade under slabs is specified in Section 31 05 05, Common Work Results for Earthwork.

B. Drainage and filter aggregates for subsurface drainage systems are specified in Section 33 46 00, Subdrainage.

1.3 REFERENCE STANDARDS

A. ASTM International (ASTM)

1.	ASTM C131	Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
2.	ASTM C136	Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
3.	ASTM C535	Standard Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
4.	ASTM D4253	Standard Test Method for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table
5.	ASTM D4254	Standard Test Method for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density
6.	ASTM D6938	Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

PART 2 - PRODUCTS

2.1 MATERIALS

A. Aggregate Drainage Fill:

1. Aggregate drainage fill for capillary break under concrete slabs shall consist of broken stone, crushed or uncrushed gravel, clean quarry waste, or a combination thereof, free from adobe, vegetable matter, loam, volcanic tuff, and other deleterious substances. It shall be of such quality that the absorption of water in a saturated surface dry condition does not exceed 3 percent of the oven dry weight of the samples.

2. Aggregate drainage fill shall be of such size that the percentage composition by dry weight as determined by laboratory sieves (U.S. Series) will conform to the following grading when measured in accordance with ASTM C136:

Sieve Size	Percentage Passing Sieves
1-1/2 inches	100
1 inch	90-100
No. 4	0-5

3. Percentage wear when tested in accordance with ASTM C131 and ASTM C535 shall be 50 percent maximum.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Inspect prepared subgrade or subbase and document inspection in accordance with the Contractor's Quality Management Plan before proceeding with placing of the aggregate drainage fill.

B. The subgrade or subbase to receive aggregate drainage fill shall conform to the compaction and elevation tolerances indicated for the material involved and shall be free of standing water and loose or extraneous material.

3.2 INSTALLATION

A. Aggregate Drainage Fill:

1. Pipes, drains, conduits, and any other mechanical or electrical installations shall be in place before any aggregate drainage fill is placed. Backfill at walls to elevation of drainage fill shall be in place and compacted.
2. Aggregate drainage fill under concrete slabs shall be the minimum uniform thickness after compaction of dimensions indicated. Where not indicated, minimum thickness after compaction shall be 4 inches.
3. Aggregate drainage fill shall be compacted with appropriate compaction equipment to form a well-compacted bed. Provide for relative density of 75 percent as determined by ASTM D4253, Dry Method, and ASTM D4254, Method A.
4. Heavy equipment shall not be used within 4 feet of concrete walls. Instead, aggregate drainage fill shall be compacted with suitable light equipment, such as hand-held mechanical tampers.
5. Inspect the finished aggregate drainage fill and obtain the Contractor's engineer's approval before proceeding with subsequent construction.

B. Vapor Retarder Installation: Lay vapor retarder membrane over the compacted aggregate drainage fill in accordance with vapor retarder manufacturer's written instructions.

3.3 FIELD QUALITY CONTROL

A. Perform field tests in accordance with ASTM D6939 to determine compliance with specified requirements for density and compaction of the installed aggregate drainage fill.

END OF SECTION

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SECTION 31 35 00

SLOPE PROTECTION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Slope paving.

B. Channel paving.

C. Crib walls.

D. Rock slope protection.

1.2 SLOPE PROTECTION CLASSIFICATION

A. Block Paving: Precast concrete block units with mortar-filled or grouted joints.

B. Stone Paving: Quarry stone laid in uniform courses with broken joints filled with mortar or grout.

C. Concrete Paving: Monolithic concrete paving.

D. Shotcrete (Air-Blown Mortar): Mixed fine aggregate and Portland cement pneumatically applied.

E. Crib Wall: Earth-retaining structure constructed of interlocking, reinforced precast concrete crib-wall members; there are both "open-faced" or "closed-face" type structures.

F. Riprap: Hard, durable, angular stone or rock placed to produce a well-graded mass of stone not less than 2-feet thick.

1.3 REFERENCE STANDARDS

A. ASTM International(ASTM):

1. ASTM C33 Standard Specification for Concrete Aggregates
2. ASTM C90 Standard Specification for Loadbearing Concrete Masonry Units
3. ASTM C91 Standard Specification for Masonry Cement
4. ASTM C144 Standard Specification for Aggregate for Masonry Mortar
5. ASTM C150 Standard Specification for Portland Cement
6. ASTM C568 Standard Specification for Limestone Dimension Stone
7. ASTM C615 Standard Specification for Granite Dimension Stone
8. ASTM C915 Standard Specification for Precast Reinforced Concrete Crib Wall Members

B. State of California, Department of Transportation (Caltrans), Standard Specifications:

1. Section 53 Shotcrete
2. Section 72 Slope Protection

3. Section 88 Geosynthetics

1.4 SUBMITTALS

A. Product Data: Submit data for pavers, crib wall components, riprap, mix designs for mortar or grout, and other accessories.

1.5 SITE CONDITIONS

A. Do not grout slope or channel paving or place concrete slope paving when the temperature falls below 50 degrees F. During cold weather, provide protective coverings for the work.

B. Perform no grouting or concrete work when it is forecasted that the temperature will drop below 32 degrees F within four days following its installation. Should any work be exposed to temperature of 40 degrees F or below, within four days after grouting or concrete placement, cover the work with a one-foot thick layer of straw, hay, or mulch; then cover with a weighted cover of canvas or plastic sheet.

PART 2 - PRODUCTS

2.1 MATERIALS FOR PAVING

A. Concrete Block Pavers: Precast concrete block units conforming to ASTM C90, 4 inches by 12 inches by 16 inches in size unless otherwise indicated.

B. Stone Pavers: Quarry stone of granite, limestone, or other similar durable stone; rectangular exposed surface with split or quarry face finish; uniform in color; 12 to 28 inches long, 10 to 14 inches wide, 4 to 6 inches thick, conforming with ASTM C568 or ASTM C615 as applicable.

C. Bedding Material: Clean and graded sand passing a No. 4 U.S. Standard sieve, conforming generally to ASTM C33 requirements for fine aggregate, or masonry sand conforming to ASTM C144.

D. Mortar and Grout: Mortar or grout for filling of joints or voids between block and stone pavers shall be ASTM C270, Type M mortar using ASTM C91, Type M masonry cement or ASTM C150, Type I or II portland cement, and ASTM C144 aggregate. Adding of lime will not be permitted. Minimum strength at 28 days: 2,500 psi .

E. Concrete: Refer to Section 03 30 00, Cast-In-Place Concrete, Section 03 05 15, Portland Cement Concrete, and Section 03 35 00, Concrete Finishing, for requirements. Provide minimum Class 3000 concrete.

F. Shotcrete: Refer to Section 03 37 13, Shotcrete, and Caltrans Standard Specifications, Section 53, for requirements.

2.2 CRIB WALLS

A. Provide crib-wall units as indicated conforming to ASTM C915. Crib-wall shall be "open-faced" or "closed-face" as indicated or appropriate for the soil conditions with approval from the Contractor’s geotechnical engineer.

2.3 ROCK SLOPE PROTECTION

A. Provide materials in accordance with Caltrans Standard Specifications Sections 72-2, 72-3, or 72-4, and as indicated in the Construction Specifications.

PART 3 - EXECUTION

3.1 SLOPE PAVING

A. Aggregate Base: Place concrete blocks, stone, or concrete over an approved compacted aggregate subbase or base in accordance with applicable requirements of Section 32 11 23, Aggregate Base Courses.

B. Block Paving: Lay block pavers in minimum 2-inch thick sand bedding material, in uniform courses with joints not exceeding 1 inch in width. Securely bed pavers and then fill joints with mortar or grout to the top of the paved surface. Minimum thickness or depth of mortar joints: 2 inches. Cover completed paving and keep wet for a minimum period of 5 days.

C. Stone Paving: Comply with requirements specified above for block paving, except that stone paving shall have broken joints not exceeding 2 inches in width. Where necessary, chink interstices with smaller stones. Fill joints with mortar or grout to top of paved surface.

D. Concrete Paving: Comply with applicable requirements of Section 03 30 00, Cast-In-Place Concrete, and Section 03 35 00, Concrete Finishing. Provide minimum 4-inch thick concrete. Provide coarse "broom finish" and curing as specified in Section 03 35 00, Concrete Finishing.

E. Shotcrete: Comply with applicable requirements of Section 03 37 13, Shotcrete, and Caltrans Standard Specifications, Section 53.

3.2 CHANNEL PAVING

A. Comply with requirements specified above for slope paving.

3.3 CRIB WALLS

A. Provide crib-wall construction as indicated and in accordance with applicable requirements of ASTM C915. Provide wall surface that is approximately parallel to, and within 6 inches of, the slope indicated.

3.4 ROCK SLOPE PROTECTION

A. Construct as specified the Caltrans Standard Specifications Sections 72-2, 72-3, or 72-4, and as indicated in the Construction Specifications.

3.5 FIELD QUALITY CONTROL

A. Incorporate field quality control requirements in Contractor’s Quality Management Plan including tolerances of paving, crib walls, and riprap. Contractor’s Quality Management Plan shall incorporate applicable requirements of the referenced standards.

B. Perform tests and other procedures to verify quality in accordance with Contractor's Quality Management Plan.

END OF SECTION

SECTION 31 35 33

TURF AND HYDROSEED SLOPE PROTECTION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Turfgrass sod installation

B. Hydroseeding

1.2 SLOPE PROTECTION CLASSIFICATION

A. Turf: Soil bound by grass and roots into a close mat; sod.

B. Hydroseeding: Slurry mixture of seed, mulch, fertilizer, and water, applied to ground areas under pressure with hydraulic hydro-seeder equipment.

1.3 SUBMITTALS

A. Product Data: Submit data for seed mix, fertilizer, mulch, and other accessories.

1. Submit documentation for each seed bag delivered including species, purity, percent germination, dealer's guarantee, and dates of test.

PART 2 - PRODUCTS

2.1 TURF AND ACCESSORIES

A. Provide turfgrass sod with a grass mix selected for the location where it will be installed.

B. Where turf is required to match existing adjacent slopes, provide turf or sod matching the adjacent grass in species and color.

C. Staples for turfgrass sod shall be U or T shaped steel wire having minimum gauges of No. 11 and No. 8, respectively. The U shaped staples shall average 1 to 1-1/2 inches wide. The T shaped staples shall have a main and secondary leg and a 4-inch head. The U shaped staples shall be a minimum length of 6 inches and the T shaped staples shall have a main leg length of 8 inches and a secondary leg of 1 inch.

2.2 HYDROSEEDING MATERIALS AND EQUIPMENT

A. Mulch:

1. Composition: Green-colored, fibrous, 100 percent virgin wood fiber mulch containing no growth or germination-inhibiting factors. Dye shall be nontoxic.
2. Dispersion in Slurry: Mulch shall be manufactured in such manner that, after addition to and agitation in slurry tanks with fertilizer, seed, water, and other approved additives, fibers in the material will become uniformly suspended to form a homogeneous slurry.

3. Absorption Capacity: When hydraulically sprayed on the ground, mulch shall form a blotter-like ground cover impregnated uniformly with seed which will allow the absorption of moisture and rainfall to percolate to the underlying soil.
4. Weight: Weight specifications of this material from suppliers, and for all applications, refers to air-dry weight of the fiber material. Absolute air dry weight is based on standards of the Technical Association of the Pulp and Paper Industry for wood cellulose and is considered equivalent to 10 percent moisture.
5. Labeling: Each package of cellulose fiber shall be marked by the manufacturer to show the air-dry weight content.

B. Seed: Types of seed as selected by the Contractor and accepted by the Contracting Officer for the location where it will be installed or as specified in the Construction Specifications.

1. Seeds shall be in conformance with the California State Seed Law of the Department of Agriculture. Deliver each seed bag to the site sealed and clearly marked as to species, purity, percent germination, dealer's guarantee, dates of test, and the amount of Pure Live Seed (PLS) contained.

C. Fertilizer: A complete commercial fertilizer composed of natural organic material or derivatives as selected for the seed mix and location conforming to the requirements of the California Food and Agricultural Code.

D. Water: Potable water. Furnish and transport as required.

E. Hydroseeding Slurry Mix: Mixture shall be composed of the following proportions for each 1,000 square feet of coverage:

Mulch	28 pounds
Seed	As selected for the application location and type of seed.
Fertilizer	11 pounds
Water	40-60 gallons

F. Hydroseeding Equipment:

1. Mixer: Commercial type hydro-seeder for application of slurry. Equipment shall have a built-in agitation system with an operating capacity sufficient to agitate, suspend, and homogeneously mix the slurry.
2. Distribution Lines: Large enough to prevent stoppage and to provide even distribution of slurry over the ground.
3. Pump Capacity: 150 psi at the nozzle.
4. Slurry Tank: Minimum capacity of 1,000 gallons, mounted on a traveling unit with the slurry tank and spray nozzles in proximity close enough to the areas to be seeded to provide uniform distribution without waste.

PART 3 - EXECUTION

3.1 TURFGRASS SOD INSTALLATION

A. Install turfgrass sod between the dates indicated in the Construction Drawings or Construction Specifications.

B. Install turfgrass sod at indicated locations, and establish its growth and stability. Turfgrass sod shall be installed and established by a qualified landscape installation entity. Provide grass-establishment period of 30 calendar days. Replace turfgrass sod that does not display healthy growth.

C. Place turfgrass sod without breaking, tearing, or loss of soil.

D. Place sod with close joints and no overlapping. No cracks will be permitted between pieces of sod. Tamp and roll sod after placing to close the seams between the sod pieces and to press the sod tightly against the soil surface. Hand tampers and rollers shall be used to assure contact between the sod roots and the soil beneath.

E. On slopes 2:1 and steeper, place sod with the long edges parallel to the contour starting at the bottom of the slope. Successive strips shall be neatly matched and all joints shall be staggered or broken. When placing sod in ditches, the length of the strip shall be laid parallel to the direction of flow of the water.

F. Securely stake each strip or section of sod placed on slopes 2:1 or steeper and surface drainage ditches with U or T shaped metal staples placed not more than 2 feet apart and driven flush with the top of the sod.

G. Water each section of sod thoroughly a minimum of three times after placement. The first watering of sod shall be within 4 hours after being placed and shall wet the soil to a depth of 3 inches below the sod.

H. Water the sodded areas to maintain a stand of grass of uniform density and color typical of a well-established stand of the species as approved by the Contractor’s landscape architect.

I. Repair any sodded area damaged during the life of the Contract. This includes erosion damage.

3.2 HYDROSEEDING

A. Hydroseeding shall be performed during the periods specified in the Construction Drawings or Construction Specifications.

B. Examination:

1. Verify that areas to receive hydroseeding are clear of stones larger than 1-1/2 inches in diameter, weeds, debris, and other extraneous materials.
2. Verify that grades are within 1 inch, plus or minus, of the required finished grades.
3. Verify that topsoil is in proper planting condition to receive and accept hydroseed slurry.

C. Preparation: Apply water, as necessary, to bring soil to optimum moisture content for planting.

D. Slurry Mixing:

1. Perform slurry preparation at the site in accordance with mixer manufacturer’s written instructions. .

E. Application:

1. Apply slurry mix in a sweeping motion to form a uniform mat at the specified rate. Keep hydroseeding within designated areas and keep from contact with other plant materials.

2. Slurry mixture that has not been applied within 4 hours of mixing shall be discarded. Promptly remove from the site.

F. Reseeding: Reseed areas and parts of areas which fail to show a uniform stand, density, and color of seeded plants after 21 days, until all areas are covered with a satisfactory stand of plants typical of a well-established stand of the species as approved by the Contractor's landscape architect and accepted by the Contracting Officer.

G. Clean-up and Protection: Wash off slurry overspray from other plant materials, planting areas, paved areas, and structures.

H. Do not operate any equipment over hydroseeded areas.

I. Establishment of Hydroseeded Plants:

1. Establishment period shall be a minimum of 30 days. Commence establishment work immediately after completion and acceptance of the initial hydroseeding application.
2. If, during the establishment period, areas are lacking in sufficient seed to assure an adequate coverage by plants, re-cultivate and reseed such areas shall be within 24 hours after observation or within 24 hours after written notification from the Contracting Officer.
    a. The establishment period, in this case, shall be continued until the work meets specified requirements.

3. The establishment period shall include continuous operation of watering, weeding, fertilizing, spraying, insect and pest control, and any other normal operation required to assure proper growth.

3.3 FIELD QUALITY CONTROL

A. Incorporate field quality control requirements in Contractor's Quality Management Plan.

B. Perform tests and other procedures to verify quality in accordance with Contractor's Quality Management Plan.

END OF SECTION

SECTION 31 38 13

REINFORCED SLOPES AND EARTH STRUCTURES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Furnishing materials.

B. Geogrid selection.

C. Geogrid criteria.

D. Field quality control.

E. Submittals and Drawings.

F. Placement and Installation.

1.2 RELATED SECTIONS

A. Section 03 40 00, Precast Concrete.

B. Section 31 05 00, Common Work Results for Earthwork.

1.3 DEFINITIONS

A. Earth structure system: A system of soil, reinforcement and facing designed to maintain relatively steep slopes.

B. Inclusion: A generic term that encompasses all man-made elements incorporated in the soil to improve its behavior. Examples of inclusions are geotextile sheets or polymeric geogrids, and tendons between anchorage elements. The term reinforcement is used only for those inclusions where soil-inclusion stress transfer occurs continuously along the inclusion.

C. Mechanically Stabilized Earth Wall (MSE wall or MSEW): a generic term that includes reinforced soil (a term used when multiple layers of inclusions act as reinforcement in soils placed as fill).

D. Reinforced Soil Slopes (RSS): A form of reinforced soil that incorporates planar reinforcing elements in constructed earth-sloped structures with face inclinations from horizontal of less than 70 degrees.

E. Geosynthetics: A generic term that encompasses flexible polymeric materials used in geotechnical engineering such as geotextiles, geomembranes, geonets, and geogrids.

F. Geogrid: An open mesh grid structure specifically fabricated for use as soil reinforcement.

G. Geotextile: A fabric formed from synthetic fibers manufactured in a woven or loose nonwoven manner which, when used in association with soil, has the ability to separate, filter, reinforce, protect, or drain.

H. Facing: A component of the reinforced soil system used to prevent the soil from raveling out between the rows of reinforcement. Common facings include precast concrete panels, dry cast modular blocks, gabions, shotcrete, timber lagging and panels, polymeric cellular confinement systems, and wrapped sheets of geosynthetics. The facing also plays a minor structural role in the stability of the structure. For RSS structures it usually consists of geosynthetic wrap-around or some type of erosion control material.

I. Retained backfill: Fill material located behind the mechanically stabilized soil zone.

J. Reinforced fill: Fill material in which the reinforcements are placed.

1.4 REFERENCE STANDARDS

A. ASTM International (ASTM):

1. ASTM D4873 Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples

1.5 SUBMITTALS

A. Product Data: Submit product data on geosynthetics soil reinforcement and related products complete with lists of test standards, methods, and corresponding values. Submit product data for pipe underdrains.

B. Design Submittals: Submit design drawings, design calculations, and any system-specific specifications prepared by the system supplier for approval at least 60 days prior to the beginning of earth structure systems construction. The calculations and drawings shall be prepared and sealed by a Professional Engineer, licensed in the State of California.

C. Shop Drawings and Calculations: Submit complete shop drawings for each installation of the earth structure system.

1. Verify the existing ground elevations at the site before preparing shop drawings. Shop drawings shall contain all information required for the construction of the earth structure system at each location including existing ground line at face of wall as verified at the site and any required revisions or additions to drainage systems or other facilities. Shop drawings shall include “General Notes” that contain design parameters, material notes, and wall construction procedures and shall be accompanied with calculations. Shop drawings and calculations shall be stamped and signed by a Professional Engineer who is registered as a Civil Engineer in the State of California. The signer of the shop drawings and calculations shall document on the shop drawings all assumptions made in the design.

D. Record Drawings (As-Builts): Unless otherwise specified, at the completion of each earth structure system for which shop drawings were submitted and if the work detailed in these shop drawings is permanent, submit Record Drawings in accordance with Contract requirements, including electronic files, showing as-built conditions. As-built drawings that are common to more than one structure shall be submitted for each structure.

E. Certificates of Compliance:

1. Submit a manufacturer's certification of compliance that the geosynthetics supplied meet the respective index criteria set when the geosynthetic type was approved by the Contractor's geotechnical engineer. The certifications shall indicate that the geosynthetic soil reinforcement and related products meet the requirements set forth in the respective material specifications and product data including all test methods and standards. Submit manufacturer's certifications for acceptance at least 60 days prior to start of earth structure systems construction.
2. Submit certificates of compliance for pipe underdrains, drainage rock, and backfill material to be used.

F. Field Construction Manual: Prior to fabrication, submit a field construction manual for proposed earth structure systems. This manual shall provide step-by-step instructions for the proposed construction.

G. Qualifications of Supplier: Submit qualifications of supplier.

1.6 REGULATORY REQUIREMENTS

A. Regulatory requirements that govern the work of this Section include the following governing codes:

1. California Code of Regulations, Title 8, Chapter 4, Subchapter 4 — Construction Safety Orders, and Subchapter 19 — Trench Construction Safety Orders.
2. California Code of Regulations, Title 24, Part 2, California Building Code, Chapter 33, Safeguards during Construction, and Structural Chapters 18 and 18A, Soils and Foundations.

1.7 DESIGN REQUIREMENTS

A. Refer to CHSTP Design Criteria for design requirements for the work of this Section including: Design life, loading conditions, stability requirements, and other design criteria.

1.8 QUALIFICATIONS OF SUPPLIER

A. Earth structure / MSE wall supplier shall have a minimum of 10 years of experience in designing, manufacturing, and supplying the proposed system in the United States, and shall have completed five projects in which the proposed system has been constructed and designed. For earth structure/ MSE walls designed to support railroad loading, the supplier shall have completed five projects in which the proposed system has been constructed and designed to support railroad loading.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Geosynthetic soil reinforcement roll identification, storage, and handling shall be in accordance with ASTM D4873.

B. If storage of precast units at the site is necessary, store units in a manner that will prevent cracking, distortion, staining, or other damage and in accordance with suppliers' recommendations. Support members at their normal support points.

1.10 SITE CONDITIONS

A. Refer to Article entitled "Site Conditions" in Section 31 05 00, Common Work Results for Earthwork.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Fill and Backfill:

1. General: Refer to Section 31 05 00, Common Work Results for Earthwork, and conform to the details shown on the Construction Drawings.
2. Soil fill material for RSS and MSE structures shall conform to the requirements specified in the design submittals.

B. Soil Reinforcement:

1. Soil Reinforcement shall consist of geosynthetic materials that shall be a regular network of integrally connected polymer tensile elements, with aperture geometry sufficient to permit significant mechanical interlock with the surrounding soil. Geosynthetic structure shall be dimensionally stable and able to retain its geometry under manufacture, transport, installation, construction-phase stresses, and shall have high resistance to damage during construction, ultraviolet degradation, and all forms of chemical and biological degradation encountered in the soil being reinforced.
2. Select geosynthetic material with adequate tensile strength for the proposed use, and meet properties required per design requirements (specific to each proposed earth-structures) including durability, degradation resistance, creep behavior, high-degree of modulus, protective polymer coatings, and other mechanical properties that are time-dependent.
3. Metallic reinforcing elements shall not be used.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Refer to general earthwork requirements in Section 31 05 00, Common Work Results for Earthwork, including excavation, subgrade/foundation preparation, rough grading and filling, embankment construction, filling/raising grade, backfilling, compaction, finish grading, tolerances, source quality control, and field quality control.

B. MSE walls: Begin placement and compaction of structure backfill three feet from the back face of wall panels and progress towards the free end of the soil reinforcement away from the wall. Operate compaction equipment parallel to the wall facing. The remaining width of backfill behind the wall panels shall be placed and compacted after soil reinforcement has been covered to a depth of 6 inches.

C. MSE walls: Use hand-held or hand-guided compacting equipment to compact structure backfill material within 3 feet of the facing panels.

D. Use no sheepsfoot or grid-type rollers for compacting material within the limits of the soil reinforcement.

E. Operate no tracked construction equipment directly upon the geosynthetic reinforcement. A minimum fill thickness of 6 inches is required prior to operation of tracked vehicles over the geosynthetic reinforcement. Kept turning of tracked vehicles to a minimum to prevent tracks from displacing the fill and the geosynthetic reinforcement.

F. Grade the reinforced backfill to rapidly drain away from the wall face at the end of each work shift. Berms or ditches shall be provided to direct runoff away from the earth structure system site. Do not allow surface runoff from adjacent areas to enter the earth structure system construction site.

3.2 GEOSYNTHETIC PLACEMENT

A. Install geosynthetic reinforcement in accordance with the earth structure system designer's recommendations, unless otherwise modified by these specifications. Place geosynthetic reinforcement within the compacted soil volume as shown on the Construction Drawings or Shop Drawings.

B. Place geosynthetic soil reinforcement in full-length sections. Overlap or mechanically connect adjacent rolls of geosynthetic reinforcement as applicable.

C. Place geosynthetic reinforcement in continuous longitudinal strips in the direction of main reinforcement. Joints in the design strength direction (perpendicular to the slope or wall) shall not be permitted, except as indicated on the Construction Drawings or Shop Drawings.

D. Soil reinforcement shall be tensioned in the direction perpendicular to the wall/slope face with enough force to remove any slack in the connection or in the soil reinforcement itself. Soil reinforcement shall be secured in place to prevent movement during placement of additional soil reinforcement and backfill until the initial lift of backfill is compacted.

E. After a layer of geosynthetic reinforcement has been placed, the next succeeding layer of soil shall be placed and compacted as appropriate. After the specified soil layer has been placed, the next geosynthetic reinforcement layer shall be installed. The process shall be repeated for each subsequent layer of geosynthetic reinforcement and soil.

F. During construction, the surface of the fill should be kept approximately horizontal. Geosynthetic reinforcement shall be placed directly on the compacted horizontal fill surface. Geosynthetic reinforcements shall be placed within 2 inches of the design elevations and extend the length as shown on the elevation view unless otherwise required by the Contractor's geotechnical engineer. Correct orientation of the geosynthetic reinforcement shall be verified by the Contractor's geotechnical engineer.

G. Soil reinforcement shall be covered with structure backfill during the same work shift that it is placed.

3.3 ERECTION/INSTALLATION

A. The RSS or MSE earth structure shall be constructed to the lines and grades and incorporate drainage system, as applicable, shown on the Construction Drawings. Vertical and horizontal

alignment shall be checked at every course throughout the erection process. The construction shall conform to the details shown on the Construction Drawings or approved Shop Drawings and this Section.

B. Understand that “shown” as used in the following requirements means “as shown in Construction Drawings”. The top of the RSS or MSE earth structure system shall conform to the profile shown. The bottom of structure elevations shall be at or below the elevations shown. The height and length to be used for any system shall be the minimums for that system that will effectively retain the earth behind the structure for the loading conditions and the contours, profile, or slope lines shown. The length of soil reinforcement for any system shall be not less than that shown.

3.4 FIELD QUALITY CONTROL

A. Quality Control: The Contractor shall provide quality control measures under its Quality Management Plan to ensure compliance with specified requirements. Furnish surveillance during construction performed by a California registered Geotechnical Engineer employed by the Contractor, as required to comply with the California Building Code, Chapter 33 and Chapters 18 and 18A, and other applicable regulations. Foundation and subgrade preparation, installation of geosynthetic reinforcement and wall units, and the placement and compaction of fills shall be performed under the surveillance of a California registered Geotechnical Engineer employed by the Contractor, as required to comply with the California Building Code, Chapter 33 and Chapters 18 and 18A, and other applicable regulations.

1. When special inspections are required under the California Building Code, Chapters 17 and 17A, as applicable, make arrangements through the Contracting Officer with Authority-hired inspection agency and ensure that inspections are performed.

B. Testing: Testing shall be performed by an acceptable Contractor-hired independent soils/materials testing laboratory.

C. For proprietary MSE walls: Furnish the services of a qualified representative of proprietary MSE earth retaining system manufacturer. The manufacturer’s representative shall be present during erection and backfill of the first 10 feet of height of the entire length of the wall and shall be available during any remaining installations. The manufacturer's representative shall not be an employee of the Contractor.

END OF SECTION

SECTION 31 39 13

GROUND ANCHORS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Materials, equipment, and procedures for installing ground anchors.

B. Design Requirements.

C. Quality Assurance.

D. Construction.

E. Test Anchors.

F. Load Tests.

G. Grouting of Ground Anchors.

1.2 DEFINITIONS

A. Alignment Load: A nominal minimum load applied to an anchor during testing to keep the testing equipment positioned correctly.

B. Anchor Tieback: System used to transfer tensile loads to soil or rock. Includes all prestressing steel, centralizers, spacers, anchorage devices, grout, coatings, sheathings, corrosion protection, and couplers if used, and final concrete facing.

C. Anchor: A system used to transfer tensile loads to soil or rock that includes the prestressing steel, anchorage, corrosion protection, sheathings, spacers, centralizers, and grout.

D. Anchorage: The combined system of anchor head, bearing plate, trumpet, and anchorage corrosion protection that is used to transmit the prestressing force from the prestressing steel to the surface of the ground or the supported structure.

E. Anchor Head: A device by which the prestressing force is permanently transmitted from the prestressing steel to the bearing plate.

F. Soldier Piles: See 31 50 13, Temporary Excavation Support and Protection.

G. Tremie Concrete: Concrete placed through a pipe under water or slurry, the discharge end of the pipe being kept submerged in the freshly deposited concrete so as to not disturb the concrete/slurry interface.

H. Alignment Load: A nominal minimum load applied to an anchor tieback during testing to keep the testing equipment correctly positioned.

I. Bondbreaker: A sleeve placed over the tendon in the unbonded length to ensure unobstructed elongation of the tendon during stressing.

J. Encapsulation: A corrugated or deformed tube protecting the prestressing steel against corrosion.

K. Tendon: The complete anchor assembly (excluding grout) including prestressing steel (strands or bar), corrosion protection, sheathings, coatings, and spacers and centralizers. It is the element that transfers the anchor load from the anchorage to the anchor body.

L. Bond Length: The length of the anchor tieback that is bonded to the surrounding soil and capable of transmitting the applied tensile load to the soil.

M. Tendon Bond Length: The length of the tendon that is bonded to the surrounding grout and capable of transmitting the applied tensile load to the grout.

N. Unbonded Length: The designed length of the tendon that is not bonded to the grout during stressing.

O. Centralizers: Support the tendon in the drill hole and position the tendon so grout freely flows around tendon and up drill hole.

P. Spacers: Separate the steel strands of strand tendons.

Q. Lock-off Load: The prestressing force in an anchor immediately after transferring the load from the jack to the stressing anchorage.

R. Lift-Off: Checking the load in the tendon at any specified time with the use of a hydraulic jack at the moment of lifting of the anchor head off the bearing plate.

S. Performance Test: Cyclic and incremental loading and unloading of an anchor, while recording the total movement of the pulling head in each cycle at each increment, including the residual movement at alignment load.

T. Proof Test: Incremental loading of an anchor and recording the total movement of the anchor at each increment.

1.3 REFERENCE STANDARDS

A. The work of this Section shall comply with the following standards. Where specific reference is made to the standard, the standard shall apply as specified.

B. ASTM International (ASTM):

1.	ASTM A53	Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc Coated, Welded and Seamless.
2.	ASTM A500	Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
3.	ASTM A775	Standard Specification for Epoxy-Coated Steel Reinforcing Bars
4.	ASTM A779	Standard Specification for Steel Strand, Seven-Wire, Uncoated, Compacted, Stress-Relieved for Prestressed Concrete
5.	ASTM A882	Standard Specification for Filled Epoxy-Coated Seven-Wire Prestressing Steel Strand

6. ASTM C109 Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in or [50-mm] Cube Specimens)
7. ASTM D1248 Standard Specification for Polyethylene Plastics Extrusion Materials For Wire and Cable
8. ASTM D1784 Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
9. ASTM D4101 Standard Specification for Polypropylene Injection and Extrusion Materials

C. American Association of State Highway and Transportation Officials (AASHTO):

1. AASHTO M85 Standard Specification for Portland Cement
2. AASHTO M203 Standard Specification for Steel Strand, Uncoated Seven-Wire for Concrete Reinforcement
3. AASHTO M275 Standard Specification for Uncoated High-Strength Steel Bar for Prestressing Concrete
4. AASHTO M284 Standard Specification for Epoxy-Coated Steel Reinforcing Bars: Materials and Coating Requirements

D. Post-Tensioning Institute (PTI):

1. PTI DC.35.1 Recommendations for Prestressed Rock and Soil Anchors
2. PTI TAB.1 Post-Tensioning Manual

1.4 REGULATORY REQUIREMENTS

A. Comply with applicable requirements of the California Code of Regulations, Title 24, Part 2, California Building Code, Chapters 18 and 18A, "Foundations and Retaining Walls."

1.5 SUBMITTALS

A. Submit calculations for design of the tendons, unbonded lengths, bonded lengths, bearing plates, bearing stiffeners, and wedge plates for review and approval prior to commencement of this work. Ensure calculations are prepared, sealed, and signed by the Anchor Design Engineer.

B. Shop drawings indicating tieback system and installation procedures. Drawings shall be sealed and signed by the Anchor Design Engineer. Include:

1. Anchor tieback schedule showing each anchor tieback number, design load, anchor type, anchor diameter, anchor spacing, minimum bond length, minimum tendon bond length, and minimum unbonded length.
2. Details for spacers and locations, centralizers, anchorage and trumpet.

C. Manufacturer's Instructions: Submit the following written instructions.

1. Encapsulation manufacturer's repair instructions.
2. Prestressing steel manufacturer's cutting instructions.

D. Grout mix design.

E. Mill test reports for prestressing steel and bearing plate steel.

F. Calibration data for each test jack, load cell, primary pressure gage, and reference pressure gage to be used. Calibration records shall include the date tested, the device identification number and the calibration test results, and shall be certified for an accuracy of at least 2 percent of the applied certification loads by a qualified independent testing laboratory within 90 days prior to submittal.

G. Grouting records indicating cement type, quantity injected, and grout pressures; anchor test results and graphs, and as-builts showing location and orientation of each anchor tieback, capacity, tendon type, total anchor length, bond length, and locations of all instruments.

H. Test data and results for all testing required herein.

1. Submit graph format for plotting of anchor movement versus load for approval or acceptance prior to use of format.

I. Driller's qualifications.

J. Anchor Tieback Design Engineer's qualifications.

K. Details of destressing and removal of temporary anchors.

1.6 QUALITY ASSURANCE

A. Drillers shall be skilled in anchor installation work, for the purpose of drilling and installing anchors, and have a minimum of 5 years of experience in drilling and installing work of similar scope and complexity.

B. Anchor Design Engineer shall be a professional civil or structural engineer currently registered in the State of California.

C. Welding and welders' qualifications shall conform to the applicable requirements of Section 05 05 22, Metal Welding.

D. Wherever the words "or approved equal" is used in regard to specific products, it shall be understood that the approval of an alternative product shall be by the Contractor's geotechnical engineer.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Handle and store tendons in such a manner as to avoid damage or corrosion. Reject prestressing steel damaged as a result of abrasions, cuts, nicks, welds, and weld spatter.

B. Protect prestressing steel if welding is to be performed in vicinity. Do no grounding welding leads to prestressing steel. Protect prestressing steel from dirt, rust, deleterious substances, and excessive heat. A light coating of rust on steel is acceptable. Reject tendons which have heavy corrosion or pitting.

C. Prevent excessive bending during lifting of pre-grouted tendons, which can de-bond the prestressing steel from the surrounding grout.

D. Maintain tendon bond length free of dirt, manufacturer's lubricants, corrosion-inhibiting coatings, and other deleterious substances that may significantly affect the grout tendon bond.

1.8 PROJECT CONDITIONS

A. Existing Utilities: Comply with the requirements of Section 33 05 25, Support and Protection of Existing Utilities. Verify locations of existing utilities prior to commencement of excavation activities and protect existing utilities. Proceed with caution in areas of existing structures and substructures. Carry out pre-construction surveys of existing structures and substructures as specified in Section 02 22 00, Existing Conditions Assessment and other Contract requirements.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General: Use new materials that are sound and free from strength-impairing defects.

B. Anchorage Devices:

1. Stressing Anchorages: Combination of either a steel bearing plate with wedge plate and wedges, or a steel bearing plate with a threaded anchor nut. The steel bearing and wedge plate may also be combined into a single element. Ensure anchorage devices are capable of developing 95 percent of the specified minimum ultimate tensile strength of the prestressing steel tendon. Ensure anchorage devised conforms to the static strength requirements of the PTI Post Tensioning Manual.
2. Bearing Plates: Conform to the requirements of AASHTO M183 or M222 or equivalent.
3. Wedges: Design to preclude premature failure of prestressing steel due to notch or pinching effects under static and dynamic strength requirements of the PTI Post-Tensioning Manual. Do not reuse wedges.

C. Bondbreakers: Fabricate from smooth plastic tube or pipe having the following properties:

1. Resistant to chemical attack from aggressive environments, grout or corrosion inhibiting compound;
2. Resistant to aging by ultra-violet light;
3. Fabricated from material non-detrimental to tendon;
4. Capable of withstanding abrasion, impact, and bending during handling and installation;
5. Enables tendon to elongate during testing and stressing;
6. Allows tendon to remain unbonded after lock-off.

D. Cement Grout: Type I, II, III, or V portland cement conforming to the requirements of AASHTO M85. Use grout of a pumpable neat mixture of cement and water and that is stable (bleeds less than two percent), fluid, and provides a minimum 28-day compressive strength of at least 4000 pounds per square inch (psi) measured in accordance with ASTM C109 at time of stressing. Admixtures that control bleed, improve flowability, reduce water content, and retard set may be used in the grout. Ensure admixtures are compatible with the prestressing steels and mixed in accordance with manufacturer's recommendations. Expansive admixtures may only be added to grout used for filling sealed encapsulations, trumpets, and anchorage covers.

E. Centralizers and Spacers: Plastic or material non-detrimental to prestressing steel.

F. Corrosion-Inhibiting Compound: For the corrosion-inhibiting compound placed inside the sheath in the free length, use an organic compound such as wax or grease with appropriate polar moisture displacing, corrosion-inhibiting additives and self-healing properties. Use a compound

that permanently stays viscous and is chemically stable and non-reactive with the prestressing steel, the sheathing materials, and the anchor grout.

G. Grout Tubes: Have adequate inside diameter to enable grout to be pumped to bottom of drill hole. Strong enough to withstand grouting pressures.

H. Prestressing Steel: Fabricate from single or multiple elements of one of the following prestressing steels:

1. Steel bars conforming to AASHTO M275
2. Seven-wire, low-relaxation strands conforming to AASHTO M203
3. Compact seven-wire, low-relaxation strands conforming to ASTM A779

I. Couplers: capable of developing 100 percent of minimum specified ultimate tensile strength of prestressing steel bar.

J. Sheath: Use as part of the corrosion protection system for the unbonded length portion of the tendon. Fabricate from one of the following:

1. A polyethylene tube pulled or pushed over the prestressing steel. Use Type II, III, or IV polyethylene as defined by ASTM D1248, or approved equal. Use tubing that has a minimum wall thickness of 1/16 inch.
2. A hot-melt extruded polypropylene tube. Use cell classification B55542-11 polypropylene as defined by ASTM D4101, or approved equal. Use tubing that has a minimum wall thickness of 1/16 inch.
3. A hot-melt extruded polyethylene tube. Use high density Type III polyethylene as defined by ASTM D1248, or approved equal. Use tubing that has a minimum wall thickness of 1/16 inch.
4. Steel tubing conforming to ASTM A500. Use tubing that has a minimum wall thickness of 3/16 inch.
5. Steel pipe conforming to ASTM A53. Use pipe that has a minimum wall thickness of 3/16 inch.
6. Plastic pipe or tube of PVC conforming to ASTM D1784 Class 13464-B. Use pipe or tube that is Schedule 40 at a minimum.
7. A corrugated tube conforming to the requirement of the tendon bond length encapsulation.
8. Concrete and Grout: Refer to Section 03 11 00, Concrete Forming, Section 03 20 00, Concrete Reinforcing, Section 03 30 00, Cast-In-Place Concrete, and Section 03 05 15, Portland Cement Concrete, for requirements.

2.2 DESIGN REQUIREMENTS

A. The Contractor shall be responsible for the detailed design of the ground anchor, including the determination of the applied loads, design assumptions, and installation procedures.

B. The Contractor shall be responsible for the design of the anchor testing equipment and reaction system.

C. Design the ground anchors to safely withstand the applied loads specified in the Pre-Production Test Anchor clause and fulfill the acceptance criteria specified in the Production Anchor clause and perform satisfactorily at the design load through the required service life of 100 years.

1. Exception: Temporary anchors service life shall be appropriate for their specific application.

D. Design assumptions shall accurately represent the subsurface conditions prevalent at the site.

E. Temporary anchors in a corrosive environment shall be designed as permanent anchors with the exception of their service life.

F. Except as specified in this Section, design ground anchors according to the design recommendations set forth in the PTI Recommendations for Prestressed Rock and Soil Anchors.

2.3 FABRICATION

A. Shop or field-fabricate ground anchors. Cut prestressing steel with abrasive saw or, if permitted per prestressing steel manufacturer's written instructions, an oxyacetylene torch. Perform pre-grouting of encapsulated tendons on an inclined, rigid frame or bed by injecting grout from low end of tendon.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Select the drilling method, grouting procedure, and grouting pressure to be used for installation of anchors as necessary to satisfy load test requirements.

B. Locate drill hole such that longitudinal axis of drill hole and longitudinal axis of tendon are parallel. Do not drill hole in a location that requires tendon to be bent in order for bearing plate to be connected to supported structure.

C. Prior to inserting tendon in drill hole, examine tendon for damage to encapsulation and sheathing. If required, repair encapsulation in accordance with manufacturer's written instructions. Repair damage to sheathing with high molecular weight polyethylene tape. Spiral wind the tape around the tendon to completely seal damaged area. Spiral wind at a pitch, which ensures double thickness at all points.

D. Locate tendon in the middle third of the anchor section.

E. Where centralizers are required, space them at no greater than 10 feet on center with the deepest centralizer located one foot from the end of the anchor and the upper centralizer for the bond zone located no more than 5 feet from the top of the tendon bond length.

F. Ensure spacers permit grout to freely flow around tendon and up drill hole. Place spacers at a maximum interval of 10 feet.

G. Place tendons in accordance with recommendation of tendon manufacturer. Insert tendon in drill hole to desired depth without difficulty. Do not drive or force partially inserted tendons into drill hole. Remove tendon from drill hole and clean or redrill the hole to permit insertion.

H. Control the rate of placement of tendon into drill hole such that sheathing and grout tubes are not damaged during installation of tendon. Do not subject anchor tendons to sharp bends. Bottom end of tendon may be fitted with a cap or bullnose to aid its insertion into the hole, casing, or sheathing.

I. Drill holes for ground anchors in a manner that will minimize loss of ground and at the locations and to the length, inclination, and diameter shown on Construction Drawings or approved shop drawings.

3.2 GROUTING

A. Ensure cement does not contain lumps or other indications of hydration. Use grouting equipment that produces grout free of lumps and undispersed cement.

B. Use a positive displacement grout pump. Equip the pump with a pressure gage to monitor grout pressures. Ensure pressure gage is capable of measuring pressures of at least 150 pounds per square inch or twice the actual grout pressure used whichever is greater. Size grouting equipment to enable grout to be pumped in one continuous operation. Ensure mixer is capable of continuously agitating the grout.

C. Inject grout from lowest point of drill hole. Pump through grout tubes, casing, hollow-stem augers, or drill rods. Place before or after insertion of tendon. Record quantity of grout and grout pressures. Control grout pressures and grout takes to prevent excessive heave or fracturing.

D. Do not use pressure grouting in free length zone. Ensure the grout at the top of the drill hole does not contact the back of the structure or the bottom of the trumpet.

E. Clean and protect stressing tail from damage until lock-off. After anchor has been stressed and accepted by the Contractor’s engineer cut tail to final length according to tendon manufacturer’s recommendations.

F. Install anchor bearing plate and anchor head or nut perpendicular to tendon, within plus or minus 3 degrees and centered on bearing plate, without bending or kinking of prestressing steel elements. Wedge holes and wedges shall be free of rust, grout, and dirt.

G. Dispose of spilled, discarded, and wasted grout and related materials in accordance with Contract requirements.

3.3 CORROSION PROTECTION

A. Anchorage Protection

1. Provide corrosion protection of the tendon in the vicinity of the anchorage to ensure proper protection.
2. Cover stressing anchorages permanently exposed to the atmosphere or that have a concrete cover less than 2 inches with a corrosion inhibiting compound-filled or grout-filled cover.
3. On stranded tendons, the trumpet shall be long enough to enable the tendon to make a transition from the diameter of the tendon along the free stressing length to the diameter of the tendon at the wedge plate without damaging the encapsulation.
4. Completely fill trumpet with a corrosion inhibiting compound or grout. Compounds may be placed any time during construction. Grout shall be placed after the anchor has been tested and stressed to the lock-off load.
5. Corrosion inhibiting compound filled trumpets shall have a permanent seal between the trumpet and the free stressing length of the corrosion protection.
6. Trumpets filled with grout shall have either a temporary seal between the trumpet and the free stressing length corrosion protection or the trumpet shall fit tightly over the free stressing length corrosion protection for a minimum of 1 foot.

B. Bond Length and Free Stressing Length Protection

1. Fully encase the tendon within a corrugated PVC sheathing that is in turn encased within a smooth PVC sheathing over the length of the free stressing zone and protected with grout.
2. Provide corrosion protection of the free stressing length by a sheath filled with a corrosion inhibiting compound or grout or a heat shrinkable tube internally coated with a mastic compound. The corrosion inhibiting compound shall completely coat the tendon elements, fill the void between them and the sheath, and fill the interstices between the wires of multiple wire strands. Provisions shall be made which ensure that the compound is retained within the sheath.
3. The corrosion protection sheath surrounding the free stressing length of the tendon shall be long enough to extend into the trumpet but shall not come into contact with the stressing anchorage during testing.
4. For pregrouted encapsulations, a separate bond breaker shall be provided to prevent the tendon from bonding to the grout surrounding the free stressing length.
5. Fusion bonded epoxy may be used to provide an additional layer of protection to the prestressing steel.

C. Bond Length and Free Stressing Length Transition

1. The corrosion protection surrounding the free stressing length of the tendon shall not contact the bearing plate or anchor head.
2. The transition between the corrosion protection for the bonded and free stressing lengths shall be designed and fabricated to ensure continuous protection from corrosion.

D. Coupler Protection

1. On encapsulated bar tendons, cover the coupler and any exposed bar section next to it with a corrosion proof compound or wax impregnated cloth tape. Cover the coupler area with a smooth plastic tube overlapping the adjacent sheathed tendon by at least 1 inch The two joints shall be sealed each by a coated heat shrink sleeve of at least 6 inches length. The corrosion proof compound shall completely fill the space inside the cover tube.

3.4 TOLERANCES

A. Deviation of anchor projection angle shall be not more than 2 degrees vertically and horizontally.

B. Locate the exposed end of the tieback within 6 inches of the location shown on the Construction Drawings or approved shop drawings.

C. Anchor clearance to existing utilities or foundations shall be not less than 3 feet.

3.5 FIELD QUALITY CONTROL - GENERAL

A. Anchor Tieback installation: Retain the services of a geotechnical engineer to observe the installation, including observation and recording of tests.

3.6 STRESSING, LOAD TESTING, AND ACCEPTANCE OF GROUND ANCHORS

A. Test each ground anchor. Do not apply a load greater than 10 percent of the design load to the anchor prior to testing. Do not apply a maximum test load greater than 80 percent of the specified minimum ultimate tensile strength of the prestressing steel of the tendon. Simultaneously apply

test loads to the entire tendon. Stressing of single elements of multi-element tendons is not permitted.

B. Test Equipment

1. Use a dial gage or vernier scale capable of measuring displacement to 0.001 inch to measure tendon movement. Ensure it has adequate travel so total movement can be measured without resetting the device.
2. Use a hydraulic jack and pump to apply the test load. Use the jack and a calibrated pressure gage to measure the applied load. Use a pressure gauge that is graduated in 100 psi increments or less. When the theoretical elastic elongation of the total anchor length at the maximum test load exceeds the ram travel of the jack, include the procedure for recycling the jack ram in the working drawings. Apply each increment of test load in 1 minute or less.
3. Maintain a calibrated reference pressure gage at the site. Calibrate the reference gage with the test jack and pressure gage. Provide an electrical resistance load cell and readout when performing a creep test.
4. Place the stressing equipment over the tendon in such a manner that the jack, bearing plates, load cell, and stressing anchorage are axially aligned with the tendon and the tendon is centered within the equipment.

C. Performance Test

1. Conduct at least one pre-production test anchor in each significantly different ground condition. Drill and install the performance test anchor in the same manner as the production anchors, with the exception that additional or larger tendons should be included so that the test load does not exceed 80 percent of the specified minimum ultimate tensile strength of the prestressing steel of the tendon. Changes in methods, personnel, materials or equipment may require additional performance testing as determined by the Contactor’s geotechnical engineer.
2. Performance test selected anchor as indicated in the following schedule. Raise load from one increment to another immediately after recording tendon movement.
3. Measure and record tendon movement to the nearest 0.001 inch with respect to an independent fixed reference point at the alignment load and at each increment of load. Monitor load with a pressure gage. Place reference pressure gage in series with the pressure gage during each performance test. If load determined by reference pressure gage and load determined by pressure gage differ by more than 10 percent, recalibrate the jack, pressure gage, and reference pressure gage. At load increments other than the maximum test load, hold the load just long enough to obtain the movement reading.

4. Performance Test Schedule

Load	Load (continued)
Alignment Load (AL)	AL
0.25P*	0.25P
AL	0.50P
0.25P	0.75P
0.50P*	1.00P
AL	1.50P*
0.25P	AL
0.50P	0.25P
0.75P*	0.50P
AL	0.75P
0.25P	1.00P
0.50P	1.50P
0.75P	2.00P* = Maximum performance test load
1.00P*	Reduce to lock-off load (0.80P)

* = Graph required, as specified herein.
AL = alignment load
P = design load

5. Record the anchor movement relative to the fixed reference point for the maximum performance test load at 0 time, 30 seconds, 1 minute, 2 minutes, 3 minutes, 5 minutes, 6 minutes, and 10 minutes. Also record at 20 minutes, 30 minutes, 50 minutes, and 60 minutes if creep criteria are not met at 10-minute interval. Re-pump the jack as necessary in order to maintain a constant load.
6. Creep Criteria are as follows:
   a. Total anchor movement between the 1- and 10-minute intervals shall not exceed 0.04 inch.
   b. Total anchor movement between the 6- and 60-minute intervals (if required) shall not exceed 0.08 inch.

7. Construct a graph showing a plot of anchor movement versus load for each load increment marked with an asterisk (*) in the performance test schedule, and a plot of the residual anchor movement at each alignment load versus the highest previously applied load.

D. Proof Test

1. Proof-test all production anchors as indicated in the following schedule. Raise the load from one increment to another immediately after recording of the tendon movement.

2. Proof Test Schedule

Load
Alignment Load (AL)
0.25P
0.50P
0.75P
1.00P
1.20P
1.33P = Maximum proof test load; Evaluate creep
Reduce to lock-off load (0.80P)

P = design load

3. After reaching the maximum proof test load of 1.33P, maintain the load for 10 minutes to evaluate creep based on the observed deflection behavior. Record measurements at 0 time, 30 seconds, 1 minute, 2 minutes, 3 minutes, 4 minutes, 5 minutes, 6 minutes, and 10 minutes. If the movement between the 1-minute and 10-minute hold is equal to or exceeds the creep criteria, maintain the load for an additional 50 minutes. Record measurements at 20 minutes, 30 minutes, 50 minutes, and 60 minutes.
4. Creep Criteria are as follows:
   a. Total anchor movement between the 1- and 10-minute intervals shall not exceed 0.04 inch.
   b. Total anchor movement between the 6- and 60-minute intervals (if required) shall not exceed 0.08 inch.

5. Measure and record the tendon movement to the nearest 0.001 inch with respect to an independent fixed reference point at the alignment load and at each increment of load. Use the pressure gage and reference pressure gage to measure the applied load, and use the load cell to monitor small changes of load during the constant load-hold period. Re-pump the jack as necessary to maintain the constant load.
6. Compare the results of the proof tests to the results of the performance tests. If any significant variation from the performance test is observed, as determined by the Contractor's geotechnical engineer, re-evaluate the design capacity of this and subsequent anchors.

E. Load Test Acceptance Criteria

1. Evaluate the results of each anchor test in order to determine anchor acceptability. An anchor will be acceptable provided:
   a. The total movement obtained from a performance and proof test exceeds 80 percent of the theoretical elastic elongation of the design free stressing length.
   b. The measured creep rate during the proof test load does not exceed the specified creep criteria and is a linear or decreasing creep rate, regardless of tendon length and load.

2. Reload anchors that do not meet the first acceptance criterion up to two times from alignment load to test load and repeat the calculation on these cycles. If the criterion is still not met, do not incorporate the tieback into the wall unless detensioned to prevent transfer of load to the no-load zone. Anchors that do not meet the second acceptance criterion cannot be incorporated into the wall at their design load, but may be accepted at a lesser load either determined from other production tests or additional tests. Lock off anchors that satisfy the acceptance criteria at the design lock-off load, which is 80 percent of the tieback anchor design load.
3. When a tendon fails, modify the design or installation procedures. The modifications may include, but are not limited to, installing a replacement tendon, reducing design load by increasing the number of tendons, modifying the installation methods, increasing the bond length or changing the anchor type. Submit modifications that require changes to the structure for review to the Contractor's geotechnical engineer.
4. Retesting of anchors will not be permitted, except that re-grouted tendons may be retested.

3.7 GROUND ANCHOR DE-TENSIONING

A. De-tension temporary ground anchors in sequence with completion of permanent structure or backfill as follows:

B. Where permanent structure is to be built in direct contact with excavation support system, de-tension ground anchors after floor or walls above have attained design strength and after obtaining approval from Contractor's geotechnical engineer. Leave openings in walls as necessary to provide access to tieback for de-tensioning.

C. Where backfill is placed in direct contact with excavation support system, de-tension ground anchors after compacted backfill is placed against piles to within no more than 2 feet below center of ground anchor elevation.

END OF SECTION

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SECTION 31 50 13

TEMPORARY EXCAVATION SUPPORT AND PROTECTION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Excavation support and shoring for trench, foundation, cut and cover tunnel, and other similar excavations.

B. Worker protection.

C. Protection of adjacent improvements.

1.2 RELATED SECTIONS

A. Instrumentation for monitoring earth and structure movements, as well as subsurface water levels, is specified in Section 31 09 13, Geotechnical Instrumentation and Monitoring.

B. Excavation and other earthwork operations are specified in Section 31 05 00, Common Work Results for Earthwork.

C. Trenching for utilities is specified in Section 33 05 28, Trenching and Backfilling for Utilities.

D. Coordinate the work of this Section with the work of Section 31 23 19, Dewatering.

1.3 REFERENCE STANDARDS

A. California Code of Regulations (CCR), Title 8, Chapter 4, Subchapter 4, Construction Safety Orders.

B. State of California, Department of Transportation (Caltrans), Office of Structure Construction, Trenching and Shoring Manual.

1.4 SUBMITTALS

A. Requirements specified herein for submittals of shop drawings and calculations apply to excavation support including worker protection for trench, foundation, or similar excavation five feet or more in depth.

B. Excavation Support Systems:

1. Prepare and submit a written procedure, along with detailed drawings, of the proposed excavations and excavation support systems.
2. Include installation procedures; excavation sequence; interface details; protection measures for existing structures and facilities; coordination of instrumentation and monitoring procedures to check performance, sequence, and method of removal; and contingency plans for excessive wall or structure movements.

C. Shop Drawings: Submit detailed drawings for support systems.

D. Calculations: Submit design calculations to support Shop Drawings. Include maximum theoretical deflections of supporting members. Include calculations indicating the expected magnitude of vertical and lateral movement.

E. Where Caltrans approval for excavation support or shoring is required, submit check calculations and related documents prepared, signed, and sealed by an independent civil or structural engineer currently registered in the State of California. The check documents shall confirm the essential elements of the design and shall be prepared in accordance with the Caltrans Trenching and Shoring Manual.

F. Submit for record purposes copies of permissions from adjacent property owners for extending excavations and support systems beyond Authority property. Such permission from adjacent property owner shall be in writing, and the owner's signature, granting such permission, shall be witnessed and notarized.

G. Submit proposed engineer's resume showing required experience.

1.5 QUALITY ASSURANCE

A. Engineer preparing drawings and design calculations for support systems shall be experienced in the design and construction of excavations and excavation support systems.

B. Professional Engineer's Certification: The excavation support systems program, Shop Drawings, calculations, and test reports shall be prepared, sealed, and signed by a professional civil or structural engineer currently registered in the State of California.

1.6 CRITERIA

A. Design, furnish, install, maintain, and remove excavation support and shoring for trench, foundation, cut and cover tunnel, and other similar excavations in order to protect workers, protect the Work, and prevent damage to, or movement of, adjacent buildings, structures, utilities, and other facilities.

B. Refer to and coordinate with Section 31 09 13, Geotechnical Instrumentation and Monitoring.

C. No such plan shall allow the use of a shoring, sloping, or protective system less effective than that required by the CCR, Title 8, Chapter 4, Subchapter 4, Construction Safety Orders.

D. For temporary support of excavation located in the vicinity of structures and right-of-way of other jurisdictional authorities, including Caltrans and other railroads, comply with the requirements of the jurisdictional authority. However, in no case shall criteria be less stringent than that specified in this Article entitled "Criteria".

E. The design of the support systems shall, at minimum, taken into account the following factors, as applicable:

1. Soil and groundwater conditions.
2. Width and depth of excavation.
3. Configuration of the structure or utility line to be constructed within the cut.
4. Size, foundation type, and proximity of adjacent structures.
5. Utilities crossing the excavation, or adjacent to the excavation.
6. Requirements for traffic decking across the excavation.

7. Traffic and construction equipment surcharge adjacent to the excavation.
8. Settlements of adjacent structures.
9. Noise and vibration restrictions.
10. Effects of dewatering.
11. Lateral pressure due to earthquake.

F. Excavations and support systems cannot extend beyond the Authority property into adjacent properties above or below grade, except with written permission from adjacent property owners. Contractor shall be solely responsible for securing permission from adjacent property owners to install such temporary and permanent systems. If Contractor is unable to secure such permission, support systems shall be installed completely within the Authority property.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.1 PREPARATION

A. Document the existing conditions and monitor adjacent buildings, structures, utilities, and other facilities. Refer to Section 02 21 33, Photographic Documentation, 02 22 00, Existing Conditions Assessment, and Section 31 09 13, Geotechnical Instrumentation and Monitoring, for requirements for documentation and monitoring. Augment the documentation specified in those sections, as applicable, with maps, plans, and additional written descriptions

3.2 EXECUTION

A. Install, maintain, and remove excavation support and shoring.

3.3 REMEDIATION AND REPAIR

A. Stop work, notify the Contracting Officer, and take immediate remedial action if movement of the existing structure occurs during performance of the work and approaches the stated threshold and limiting values for ground distortions per Section 31 09 13, Geotechnical Instrumentation and Monitoring. Be responsible for interpretation of instrumentation data as input to evaluating construction and excavation performance and controlling settlements to prevent damage to structures, facilities, and utilities.

B. All construction activities shall be immediately halted when the settlement of any structure or facility reaches the limiting values and shall not be resumed until approval of the Contractor’s geotechnical engineer is obtained for remedial measures.

C. If personnel, existing utility line, utility structure, surface improvement, landscape plantings, buildings, or other structures are endangered, implement remedial measures, as required, to prevent damage and to maintain the safety of personnel and the Work. Remedial measures may include modification of construction procedures. Such damage or endangerment may include that as a result of settlement or from caving in or sloughing off of excavation.

D. All temporary tie backs shall be de-tensioned, and the design and construction sequence shall take this into account.

E. Restore existing structures to conditions equivalent to those existing prior to the start of work, including repair of settlement-related damage.

3.4 REMOVAL OF EXCAVATION SUPPORT SYSTEMS

A. If removal is required wholly or in part, perform such removal in compliance with jurisdictional authorities and in a manner that will not disturb or damage adjacent buildings, structures, construction, or utilities. Fill voids immediately with lean concrete or with approved backfill compacted to the relative compaction for the location as specified in Section 31 05 00, Common Work Results for Earthwork.

END OF SECTION

SECTION 31 62 00

DRIVEN PILES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Materials, equipment, and procedures for driving piles.

B. Pile Types.

C. Determination of Length.

D. Indicator Piles and Test Piles.

E. Axial Compression and Tension Load Tests.

F. Lateral Load Tests.

G. Dynamic Pile Testing.

H. Installation of Piles.

1.2 DEFINITIONS

A. Indicator Pile: An individual pile that is tested and observed to determine its behavior during driving.

B. Test Pile: An individual pile which is tested and observed under static axial compression or tension load, under lateral load, and under dynamic load tests.

C. Reaction Pile: An individual pile that provides the reaction load required to perform the load test on a test pile. During this process the reaction pile can be subjected to either an axial compression load or an axial tension load, or lateral load.

D. Production Piles: Piles that are purchased and delivered for incorporation in the permanent structure.

E. Contractor's Geotechnical Engineer: Geotechnical engineer who is part of the Contractor's organization and licensed in the State of California to practice geotechnical engineering.

F. Contractor's Structural Engineer: Structural engineer who is part of the Contractor's organization and licensed in the State of California to practice structural engineering.

1.3 REFERENCE STANDARDS

A. ASTM International (ASTM):

1. ASTM A252 Specification for Welded and Seamless Steel Pipe Piles

2. ASTM A690 Specification for High-Strength Low-Alloy Nickel, Copper, Phosphorus Steel H-Piles and Sheet Piling with Atmospheric Corrosion Resistance for Use in Marine Environments
3. ASTM D1143 Test Methods for Deep Foundations Under Static Axial Compressive Load
4. ASTM D3689 Test Methods for Deep Foundations Under Static Axial Tensile Load
5. ASTM D3966 Test Methods for Deep Foundations Under Lateral Loads
6. ASTM D4945 Test Method for High-Strain Dynamic Testing of Deep Foundations

B. American Welding Society (AWS):

1. ANSI/AWS D1.1 Structural Welding Code - Steel

1.4 REGULATORY REQUIREMENTS

A. Comply with applicable requirements of the California Code of Regulations, Title 24, Part 2, California Building Code, Chapters 18 and 18A, "Foundations and Retaining Walls."

1.5 SUBMITTALS

A. Shop Drawings: Submit Shop Drawings of pile types as follows:

1. Type A, Steel H-piles: Show typical details of size, weight, splices, tip construction, connection to pile cap, and welding of splice connection. Location and design of splices subject to Contractor’s structural engineer’s approval.
2. Type B, Concrete filled steel pipe piles: Show typical details of sizes, configuration, tip construction, connection to pile cap, and welding of section connection, details for developing composite behavior between the concrete and steel pipe, and class of concrete fill. Location of section connections subject to Contractor’s structural engineer’s approval.
3. Type C, Pre-cast, pre-stressed concrete piles: Show typical details of sizes, configuration, pre-stressing steel, tendon arrangement, class of concrete, lifting devices, curing methods, and pre-stressing methods. Include engineering calculations of working stresses. If splicing is required, submit details. Splicing, design, and location of splices subject to Contractor’s structural engineer’s approval.
4. Test Piles: Show tension steel reinforcement and connections for uplift loads.

B. Pile Driving Sequential Layout:

1. Submit layout drawings showing the proposed sequence of driving the piles.
2. On the sequential layout, show each pile by identification, its driving sequence number, type, size, load bearing capacity, and pile tip elevation as planned.
3. Submit a pile numbering plan that clearly identifies and numbers each pile for reference.

C. Pile Tip Elevations: Submit a list and plan prepared by the Contractor’s geotechnical engineer showing recommended pile tip elevations after completion of driving of indicator piles and load-testing of test piles for the Contracting Officer’s acceptance. After receipt of Contracting Officer’s acceptance, Contractor shall order piles to correct length to meet recommended pile tip elevation and cutoff elevation.

D. Pile Driving Record. Maintain a pile driving record during pile driving and submit it upon completion of each day's pile driving. On the record indicate, for each pile driven, the information specified in Paragraph entitled "Pile Driving Sequential Layout" in this Article, and the following: type and rating of driving equipment, overall blow count per foot and number of blows per inch penetration for the last 12 inches, and any unusual conditions encountered during driving. Also record start and end time of pile installation.

   1. The Contractor shall submit a certified copy of the pile driving record to the Contracting Officer for record purposes within 7 days following completion of the pile driving.

E. Pile Driving Analyzer (PDA) and Case Pile Wave Analysis Program (CAPWAP) Records: Submit the PDA and CAPWAP results to the Contracting Officer within five days following completion of the PDA testing.

F. Immediately following completion of load testing, submit two copies of the test report for each test pile to the Contractor's geotechnical engineer for review and approval. Submit copy to the Contracting Officer. Include in the test report the data required by ASTM D1143 and ASTM D3689, as applicable.

G. Equipment Review and Drawings:

   1. Submit the completed "Pile and Driving Equipment Data" form located at the end of this Section to the Contracting Officer a minimum of 14 days before driving of piles.
   2. Submit complete list of the equipment proposed for use, including a description of the characteristics of each piece of driving equipment.
      a. Indicate on the submittals that the Contractor's geotechnical engineer has reviewed the proposed driving equipment, accessories, and methods and checked the adequacy of the equipment and methods for the conditions expected to be encountered.
      b. Should the equipment used by the Contractor prove to be inadequate to drive the scheduled types of piles at the locations indicated or should the use of accessories show damage to the piles because of inadequate or inappropriate equipment or methods, replace or use different types of equipment and accessories, or both, as appropriate for the conditions encountered. Submit the new equipment for approval prior to use.

   3. Submit Shop Drawings of driving accessories showing compatibility with the size, configuration, handling, and driving requirements of each type of pile indicated.
   4. Submit Shop Drawings showing the methods and equipment proposed for loading test piles. The load test reaction frame submittal shall be prepared and stamped by a Registered Civil Engineer registered in the State of California.

H. Specialty Consultant Qualifications: Submit qualifications of proposed specialty consultant for Contracting Officer's acceptance.

1.6 QUALITY ASSURANCE

A. Pile Requirements: General and specific pile requirements shall comply, at minimum, with the California Building Code, Sections 1807, 1808, 1810, 1807A, 1808A, and 1810A, as applicable.

B. When special inspections are required under the California Building Code, Chapters 17 and 17A, as applicable, make arrangements through the Contracting Officer with Authority-hired inspection agency and ensure that inspections are performed.

C. Piles delivered to the site that are cracked, bowed, chipped, under size, or that break under driving stresses shall be rejected. Remove such piles from the site and replace with sound piles. Piles broken under driving stresses may be cut off and left in place if approved by the Contractor's geotechnical engineer for the location.

D. Drive additional piles at locations designated by the Contractor's geotechnical engineer with written acceptance of the Contracting Officer when replacing damaged piles or piles driven out of position or alignment as specified under Article entitled "Installation Tolerances" herein.

E. Welding and welders' qualifications shall conform to the applicable requirements of Section 05 05 22, Metal Welding.

PART 2 - PRODUCTS

2.1 PILES

A. Type A Piles: Steel H-piles conforming to ASTM A690, of size and type indicated. Steel plates and welding shall conform to applicable requirements of Section 05 12 00, Structural Steel Framing, and Section 05 05 22, Metal Welding.

B. Type B Piles:

1. Shell: Steel pipe conforming to ASTM A252, Grade 2, welded or seamless, of diameter and shell thickness indicated. Steel plates and welding shall conform to applicable requirements of Section 05 12 00, Structural Steel Framing, and Section 05 05 22, Metal Welding. For closed end pipe piles, end plates shall be structurally designed and adequately connected to the steel pipe to resist predicted driving stresses at the pile tip during installation.
2. Concrete Reinforcement: Conform to applicable requirements of Section 03 20 00, Concrete Reinforcing, of grades and sizes indicated.
3. Concrete: Conform to applicable requirements of Section 03 30 00, Cast-in-Place Concrete, and Section 03 05 15, Portland Cement Concrete. Provide minimum Class 4000-1-inch concrete unless otherwise indicated.
4. Concrete Reinforcement: Conform to applicable requirements of Section 03 20 00, Concrete Reinforcing, of grades and sizes indicated.
5. Concrete: Conform to applicable requirements of Section 03 30 00, Cast-in-Place Concrete, and Section 03 05 15, Portland Cement Concrete. Provide minimum Class 4000-1-inch concrete unless otherwise indicated.

C. Type C Piles: Pre-cast, pre-stressed concrete piles, of sizes and requirements indicated, conforming to applicable requirements of Section 03 05 18, Pre-stressed Concrete. Provide minimum Class 6000-1-inch concrete unless otherwise indicated.

D. Other pile types not indicated above may be proposed subject to the acceptance of the Contracting Officer. Contractor shall provide sufficient information and time to Contracting Officer to allow a thorough understanding and review of the proposed pile type.

E. Provide cathodic protection as necessary.

2.2 PILE DRIVER

A. Equip pile driver in accordance with manufacturer's recommendations.

B. Leads:

1. Use with all types of hammers.
2. Free moving.
3. Hold in the required position with guys, stiff braces, or both. Hold the pile parallel to the leads.
4. Accommodate the maximum length of the pile segment, and extend to the lowest point that the hammer must reach. Obtain approval from the Contractor's geotechnical engineer before using the followers.

C. Driving Head: Fit the top of pile and provides full bearing.

D. Hammer:

1. With fully-operable adjustable settings.
2. Rated energy as much or greater than the value indicated on the foundation plans.
3. Install a new hammer cushion before beginning pile driving.
    a. Inspect the hammer cushion with the Contractor's geotechnical engineer present after completing 100 hours of pile driving.
    b. Replace the cushion when it loses 25 percent or more of its original thickness.

PART 3 - EXECUTION

3.1 PILE TYPES

A. Piles shall be friction piles or combined friction and end-bearing piles as indicated. Piles shall be driven to the required penetration, as indicated.

3.2 DETERMINATION OF LENGTH

A. Piles shall be of such lengths as required to develop the specified capacity, to obtain the specified penetration, and to extend into the pile cap or footing block as indicated.

B. The Construction Drawings shall indicate the required type of piling, the required compression and tension capacity, the minimum penetration, and the estimated pile tip elevation. Estimated tip elevations will be approximate, based upon subsurface explorations, and shall indicate the required lengths of indicator piles and test piles.

C. Lengths of production piles shall be determined by the Contractor from the data obtained from the driving of indicator piles and the load-testing of test piles. Refer to Article entitled "Submittals" herein for submittal of recommended pile tip elevations.

3.3 INDICATOR PILES AND TEST PILES

A. From the driving behavior and test pile data and the subsurface exploration data, the Contractor’s geotechnical engineer shall determine the tip elevations of production piles. The Contractor’s geotechnical engineer shall also determine the required penetration based upon settlement criteria or any other factors that in the opinion of this engineer are applicable to the work.

B. Based upon the information indicated on the Construction Drawings, order and drive the indicator piles and test piles. Determine compression, tension, and lateral capacities of the test piles in accordance with ASTM D1143, ASTM D4945, ASTM D3689, and ASTM D3966.

C. Drive indicator piles and test piles at the locations indicated and to the lengths specified by the Contractor’s geotechnical engineer. Drive piles with impact hammers unless otherwise indicated. In general, the specified length of indicator piles and test piles shall be greater than the estimated length of production piles in order to provide for variation in soil conditions.

D. Driving equipment used for driving indicator and test piles shall be identical to that what the Contractor proposes to use for the driving of production piles.

E. The Contractor shall excavate the ground at each indicator and test pile to the elevation of the bottom of the pile-cap footing before the pile is driven, or the Contractor may employ "followers" to compensate for the extra depth. If “followers” are used, the same “followers” shall also be used for driving production piles.

F. Drive indicator piles and test piles to a hammer blow count established by the Contractor’s geotechnical engineer at the estimated tip elevation. Mark the piles in one-foot intervals for the full length of test piles such that the marks are clearly visible during driving. Test piles that do not attain the hammer blow count specified above at a depth of 1 foot above the estimated tip elevation indicated shall be allowed to "set up" for 12 to 24 hours before being re-driven. A cold hammer shall not be used for re-drive. The hammer shall be warmed up before driving begins by applying at least 20 blows to another pile. For re-driven piles, the Contractor shall mark the piles in one inch intervals for the full length of re-drive such that the marks are clearly visible during driving.

G. If the specified hammer blow count is not attained on re-driving, the Contractor’s geotechnical engineer, with the Contracting Officer’s agreement, may direct the Contractor to drive a portion or all of the remaining pile length and repeat the "set up" – re-drive procedure. The Contractor’s geotechnical engineer, with the Contracting Officer’s agreement, may specify a longer “set-up” time before the pile is re-driven. Drive piles to the planned grade and, when not having the hammer blow count required, splice and drive piles until the required bearing is obtained.

H. Contractor’s geotechnical engineer shall prepare a record of driving of indicator and test piles that shall include the number of hammer blows per foot for the entire driven length, the as-driven length of the test pile, cutoff elevation, penetration in ground, and any other pertinent information. If re-drive is necessary, the Contractor’s geotechnical engineer shall record the number of hammer blows per inch of pile movement for the first foot of re-drive.

I. Remove indicator piles at completion of testing.

3.4 AXIAL COMPRESSION AND TENSION LOAD TESTS

A. Install test piles and reaction piles, of the same type and kind as permanent piles, in the locations indicated or at other locations as required by the Contractor’s geotechnical engineer.

1. Reinforce test and reaction piles for the full length to resist uplift loads.
2. Install test piles vertically.

B. Test piles that pass the load test in an undamaged condition and were designed to meet project design requirements may be utilized as permanent piles in the work with the approval of the Contractor’s geotechnical engineer. Reaction piles that were used to perform the pile load test and were designed to meet project design requirements may be utilized as permanent piles in the work, provided they are not damaged and that they have not moved upward more than 1/8 inch. If upward movement has occurred, piles shall be re-driven to the previous elevation.

C. Either extract damaged test piles and reaction piles and remove from the site, or, with acceptance of the Contracting Officer, cut them off 3 feet below any structure to be installed above. Holes shall be backfilled with Class 3000 concrete.

D. Compression Load Tests: Tests shall be performed in accordance with ASTM D1143. Method of load test shall follow "Quick Load Test Method for Individual Piles" as specified in ASTM D1143, Section 5.6.

1. Commence loading of test piles not sooner than 72 hours after placement of concrete or 72 hours after installation of Type C piles. Type III cement may be used in test piles to accelerate achieving necessary minimum strengths.
2. The maximum test load shall be the ultimate load or twice the service design load whichever is greater as prescribed by the Contractor’s geotechnical engineer. Apply the load in increments equal to 10 percent of the maximum test load, with a constant time interval between increments of 5 minutes. Maintain the maximum test load for not less than 15 minutes, unless the shaft has failed as determined by that engineer.
3. Remove the test load in increments equal to 25 percent of the maximum test load, with a constant time interval between increments of 5 minutes.
4. Measure the settlement and rebound of the test pile to the nearest 0.01 inch.

E. Tension Load Tests: Tests shall be performed in accordance with ASTM D3689. Method of load test shall follow "Quick Load Test Method for Individual Piles" as specified in ASTM D3689, Section 7.7. The maximum test load shall be the ultimate load or twice the service design load whichever is greater as prescribed by the Contractor’s geotechnical engineer. Apply the load in increments equal to 10 percent of the maximum test load, with a constant time interval between increments of 5 minutes. Maintain the maximum test load for not less than 15 minutes, unless the pile has failed as determined by the Contractor’s geotechnical engineer. Remove the test load in increments equal to 25 percent of the maximum test load, with a constant time interval between increments of 5 minutes.

F. Allowable bearing capacity of the test pile shall be defined as 40 percent of the failure load. For piles 24 inches or less in diameter or width, the failure load of a pile tested under axial compressive load is that load that produces a settlement at failure of the pile head equal to:

$S_f = S + (0.15 + 0.008D)$

Where:

S_f = Settlement at failure in inches
D = Pile diameter or width in inches
S = Elastic deformation of total unsupported pile length in inches

G. The Contractor’s geotechnical engineer shall require the Contractor to make additional load tests that are not indicated, in the event that the behavior of the test pile or any other pile shows any peculiarity, erratic action, or otherwise causes suspicion as to the reliability of the pile capacity.

H. Refer to the Article entitled “Submittals” herein for requirement for submitting test reports of load testing. Include in the test report the data required by ASTM D1143 and ASTM D3689, as applicable.

I. Following the completion of load tests, the Contractor’s geotechnical engineer shall make a determination of the required penetration.

3.5 LATERAL LOAD TESTS

A. Tests shall be performed in accordance with ASTM D3966. Method of load test shall follow "Standard Loading Procedures" as specified in ASTM D3966, Section 6.1.

3.6 DYNAMIC PILE TESTING

A. Contractor shall hire a specialty consultant who specializes in dynamic pile testing. Dynamic measurements shall be taken by the specialty consultant during the driving of test piles designated as dynamic load test piles. Refer to the Article entitled “Submittals” herein for requirement for submitting qualifications of specialty consultant.

B. Prior to placement in the leads, the Contractor shall make each designated concrete pile available for taking wave speed measurements and for pre-drilling the required instrument attachment holes. Pre-driving wave speed measurements will not be required for steel piles. When wave speed measurements are made, the piling shall be in a horizontal position and not in contact with other piling.

C. The Contractor shall furnish the equipment, materials, and labor necessary for drilling holes in the piles for mounting the instruments. Instruments will be attached near the head of the pile with expansion-type bolts for concrete piles or through drilled holes on steel piles.

D. The Contractor shall provide access to the pile for attaching instruments after the pile is placed in the leads. A platform with minimum size of 4 by 4 feet (16 square feet) designed to be raised to the top of the pile while the pile is located in the leads shall be provided by the Contractor.

E. The Contractor shall furnish electric power for the dynamic test equipment. The power supply at the outlet shall be 10 amp, 115 volt, 55-60 cycle, A.C. only. Field generators used as the power source shall be equipped with meters for monitoring voltage and frequency levels.

F. The Contractor shall drive the pile to the design tip elevation or other depth specified by the Contractor's geotechnical engineer. The stresses in the piles will be monitored during driving with the dynamic test equipment to ensure that the values determined do not exceed the allowable values. If necessary, the Contractor shall reduce the driving energy transmitted to the pile by using additional cushions or reducing the energy output of the hammer in order to maintain stresses below the allowable values. If non-axial driving is indicated by the dynamic test equipment measurements, the Contractor shall immediately realign the driving system.

G. The Contractor shall wait up to 24 hours and, after the instruments are re-attached, re-drive the dynamic load test pile. A cold hammer shall not be used for the re-drive. The hammer shall be warmed up before re-drive begins by applying at least 20 blows to another pile. The maximum amount of penetration required during re-drive shall be 6 inches, or the maximum total number of hammer blows required will be 50, whichever occurs first. After re-driving, the Contractor's geotechnical engineer shall either provide the cut-off elevation or specify additional pile penetration and testing for that dynamic load test pile. CAPWAP analyses of dynamic pile testing data shall be performed on data obtained for the beginning of re-drive of the driven piles.

H. The Contractor shall reduce the energy of the hammer and/or make other adjustments as necessary, if the stress exceeds the specified limit.

I. The Contractor shall conduct one analysis per foundation (abutment or bent) of the Case Pile Wave Analysis Program (CAPWAP) from the Pile Driving Analyzer (PDA) testing. The Contractor shall suspend pile driving on the foundation until the CAPWAP results are presented and the Contractor's geotechnical engineer gives notice that results indicate sufficient capacity has been obtained.

3.7 INSTALLATION OF PILES

A. Pile Types: Provide piles of the type indicated and of the length and configuration necessary to perform the following:

1. Achieve the required penetration as determined by the Contractor's geotechnical engineer;
2. Extend into the pile cap or structure footing to the location indicated; and
3. Attain indicated capacity.

B. Penetration and Bearing: Install piles to the required penetration, or to the required bearing, as determined by the various load tests performed for the purpose. Jetting will not be permitted unless specifically approved in writing by the Contractor's geotechnical engineer for the location.

C. Predrilled Holes:

1. Where piles are to be driven through new embankment and the depth of the embankment is greater than 5 feet at the pile location, drive the pile in a hole, drilled through the embankment, of diameter not greater than the smallest cross-section dimension of a square or octagonal pile or of a diameter not greater than one inch less than the diameter of a circular pile. After driving the pile, fill any annular space around the pile with grout.
2. When necessary to achieve the required penetration, drill holes of diameter not greater than 90 percent of the least cross-sectional dimension of the pile at the depth being

drilled, and drive the pile therein to the required penetration. Locations and types of pre-drilling shall be approved by the Contractor's geotechnical engineer in writing.

3. When, in the Contractor's opinion, a larger hole is needed to prevent damage to piles, submit substantiating data and obtain the Contractor's geotechnical engineer's written approval before drilling holes of larger cross-section. Holes greater than 100 percent of the cross-sectional dimension of the pile will not be permitted.

D. Pile Driving:

1. Complete embankment construction, filling, and backfilling to the required elevations before starting of pile-driving operations. Unless otherwise specified, an embankment settlement period of at least six months will be required before installation of piles.
2. Do not drive piles within 20 feet of concrete less than seven days old.
3. Drive interior footing piles before driving perimeter piles.
4. If necessary, provide adequate lateral support for installed individual piles to prevent excessive temporary flexural stresses or movement of the pile top out of tolerance.
5. Maintain the hammer coaxial with the pile during the driving operation by using a combination of driving cap and leads.
6. Investigate any sudden decrease in driving resistance for possible breakage of the pile. If a sudden decrease in driving resistance cannot be correlated to boring data or some incident in the driving, and if the pile cannot be inspected, such decrease in driving resistance will be cause for rejection of the pile.
7. Re-drive any pile that is raised during driving of adjacent piles, to the original tip elevation.
8. Splice piles only by methods and at places approved by the Contractor's structural engineer in writing.
9. Cut off piles at top elevation indicated. Repair piles that are damaged when cut off requires written approval of the Contractor's structural engineer.

E. Type A Piles:

1. Design the driving cap with grooves in the base to conform loosely to the "H" configuration of the pile. The bearing surface of the grooves shall be true, without roughness. The driving cap shall extend down the side of the pile at least four inches and shall be loosely attached to the hammer so that it will, at all times, rest squarely over the entire surface of the pile.
2. Make splices as indicated by electric-arc field welding in accordance with ANSI/AWS D1.1. Cut-off damaged portion of pile top before splicing. Take care to align the sections connected so that the axis of the pile will be straight. Refer to Section 05 05 22, Metal Welding, for welding requirements.

F. Type B Piles:

1. Protect the heads of piles from direct impact of the hammer by using an approved head block or shoe.
2. Make splices as indicated by electric-arc field welding in accordance with ANSI/AWS D1.1. Cut-off damaged portion of pile top before splicing. Take care to align the sections connected so that the axis of the pile will be straight. Refer to Section 05 05 22, Metal Welding, for welding requirements.
3. Remove rejected pipe pile and replace with new pipe. When rejected pipe pile cannot be removed, furnish and install replacements. Cut off abandoned pipe 3 feet below the

structure, and fill the abandoned pipe with controlled density fill as specified in Section 03 05 15, Portland Cement Concrete. Backfill and compact holes.

4. Concrete to be placed using tremie pipe that can extend to the bottom of the pipe. Concrete will not be allowed to free fall during placement. Vibration of the concrete will not be required except in the top 15 feet of the pipe. Discharge concrete into the hopper at a continuous and rapid rate. Any break in the placement of the concrete shall be the basis for rejection of the pile. The volume of concrete placed shall be recorded and compared to the volume of concrete required to fill the pipe. Any variance between the volume of the pipe and the volume of concrete required to fill the pipe may be the basis for rejection of the pile.
5. Pipe piles may be driven with open ends, and the soil, rock or deleterious material adequately removed with auger or by other approved method to width and depth indicated to allow concrete to bond to the inside of the pipe. Inspect driven pipe shell for internal damage and misalignment and for the presence of water, and correct damaged or defective conditions before placement of concrete. Piles partially filled with water shall be dewatered or concrete-filled using the tremie method.
6. Do not allow vibrators to penetrate concrete that has taken initial set.

G. Type C Piles:

1. Protect the heads of piles from direct impact of the hammer by acceptable cushion head block, so that no cracking, spalling, or chipping occurs.
2. If piles have extended reinforcing steel and protective concrete for driving, remove such protective concrete to expose the reinforcing steel upon completion of driving.
3. When piles are driven or cut off below the elevation of the bottom of the cap, extend the pile to the elevation of the bottom of the cap by means of a reinforced concrete extension. Obtain Contractor’s structural engineer approval of details prior to fabrication.
4. When piles have achieved design capacities and are left above the cutoff elevation, cutoff the pile to the specified cutoff elevation. If this cutoff results in excessive reinforcing steel being removed from the pile, retrofit pile as needed to meet the design intent. Obtain Contractor’s structural engineer approval of details prior to fabrication. Remove and replace such piles as cannot be retrofitted.

3.8 INSTALLATION TOLERANCES

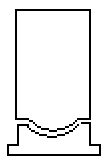
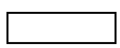
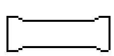
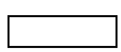
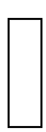
A. Deviation from plumb and angle of batter: 1/4 inch per foot of pile length, but not more than 6 inches overall.

B. Deviation from location of pile top: 6 inches.

Sheet # _____

Pile and Driving Equipment Data

Project No: ____
Project Name: ______________________________ County: _____________________________________
Drawing No: ____
General Contractor: ____
Pile Driving Contractor/Subcontractor: ____
Phone: ___________________________ FAX: ____
(Piles driven by, foreman): ____
Date Submitted: _________________

Hammer Components		**Hammer**	Manufacturer: ____________ Model: _____________ Type: ___________________ Serial No: ___________ Manufacturer=s Maximum Rated Energy: _________(ft-lb) Stroke at Maximum Rated Energy: _______________(ft) Range in Operating Energy: ____ to ____(ft-lb) Range in Operating Stroke: ____ to ____(ft) Modifications: __________________________________ ____
		Ram	Ram Weight: ________ (lb) Ram Length: _________(ft) (for diesel hammers)
		Anvil	Ram Cross Sectional Area: ____________________(in^2) (With diesel hammers) Anvil Weight: _____________(lb)
		**Hammer Cushion**	Material #1 Material #2 Name: _____________ __________ Area: _____________ __________ (in^2) No. of Plates: _____________ __________ Thickness: _____________ __________ (in) Mod. of Elasticity - E: _____________ __________ (psi) Coeff. of Restitution - e: _____________ __________
		**Pile Cap**	Helmet Bonnet Anvil Block Weight: ________________________(lb) Drive Head
		**Pile Cushion (Only for Concrete or Timber Piles)**	Material: ___________________________________ Area: ___________________________________ (in^2) No. of Sheets: ________ Thickness/Sheet: _________ (in) Total Thickness of Pile Cushion: ________________ (in) Mod. of Elasticity - E: ______________________ (psi) Coeff. of Restitution - e: ________________________
Pile		**Pile**	Diameter: __________ (in) Wall Thickness: ________ (in) Taper (if any): ________________________________ Length in Leads: _____________________________ (ft) Ordered Length: ______________________________(ft) Required Ultimate Capacity: ____________________ (lb) Description of Splice: ___________________________ Tip Treatment/Plate Description: __________________

Use Separate Data Sheet for Each Proposed Hammer and Unique Driving Condition

END OF SECTION

SECTION 31 63 29

DRILLED CONCRETE PIERS AND SHAFTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Method Test Shaft.

B. Load Test.

C. Excavation.

D. Installation of Concrete Reinforcement.

E. Concrete Placement.

F. Withdrawal of Temporary Steel Casing.

G. Field Quality Control.

1.2 DEFINITIONS

A. The words and terms used in these Specifications conform to the definitions given in ACI 336.1.

B. The terms “drilled pier” and "drilled shaft" are used interchangeably.

C. The term Contractor’s geotechnical engineer shall be understood to mean a professional geotechnical engineer registered in the State of California and experienced in the work addressed by this Section.

D. In regard to load testing, the term “site” shall be understood to be as defined in the CHSTP Design Criteria in regard to drilled concrete piers and shafts and similar work.

1.3 REFERENCE STANDARDS

A. American Concrete Institute (ACI):

1. ACI 336.1 Specification for the Construction of Drilled Piers

B. American Petroleum Institute (API):

1. API RP13B Recommended Practice for Field Testing Water-Based Drilling Fluids

C. International Association of Foundation Drilling (ADSC):

1. ADSC Standards and Specifications for the Foundation Drilling Industry (Standards and Specifications)

D. ASTM International (ASTM):

1. ASTM D1143 Method of Testing Piles Under Static Axial Compressive Load
2. ASTM D3689 Method of Testing Individual Piles Under Static Axial Tensile Load
3. ASTM D3966 Method of Testing Piles Under Lateral Loads
4. ASTM D4380 Standard Test Method for Density of Bentonitic Slurries
5. ASTM D4381 Standard Test Method for Sand Content by Volume of Bentonitic Slurries
6. ASTM D4972 Standard Test Method for pH of Soils

E. California Department of Transportation (Caltrans):

1. Caltrans California Test 233 Method of Ascertaining the Homogeneity of Concrete in Cast-In-Drilled-Hole (CIDH) Piles using the Gamma-Gamma Test Method

1.4 SEQUENCING AND SCHEDULING

A. No production drilled shafts shall be constructed until the construction methods of the test drilled shafts, the acceptance tests, and corresponding load tests are approved by the Contractor's geotechnical engineer.

B. Unless otherwise permitted by the Contractor's geotechnical engineer, the Contractor shall schedule drilling or excavating, installation of reinforcing steel, and concrete placement so that each excavated shaft is poured the same day that the drilling is performed.

C. Do not permit vibration or excessive wheel loads within the immediate vicinity of any shaft excavation until placement of concrete is complete. Maintain excavation stability at all times.

D. Do not drill a shaft for drilled pier within three diameters of an adjacent drilled pier until the concrete has set in the adjacent drilled pier.

E. When drilled shafts are to be installed in conjunction with embankment placement, the Contractor shall construct drilled shafts after the placement of fills unless shown in the approved Construction Documents. The Contractor shall not install drilled shafts prior to the completion of embankment settlement waiting period.

1.5 SUBMITTALS

A. Qualifications of the Drilled Shaft Entity: Submit a list containing at least three projects completed in the last five years on which the Contractor has installed drilled shafts of diameter and length similar to those required for the Work, and submit a signed statement that the entity which will construct drilled shafts has inspected both the project site and all the subsurface information made available in the Contract Documents and geotechnical investigations performed by the Contractor, including any soil or rock samples. Also, submit the name and experience record of the drilled shaft superintendent who will be in charge of drilled shaft operations for this project.

B. Drilled Shaft Sequential Layout:

1. Submit layout drawings showing the proposed sequence of drilling and construction of the shafts.

2. On the sequential layout, show each pile by identification, its construction sequence number, type, size, load bearing capacity, and pier tip elevation as planned.
3. Submit a drilled shaft numbering plan that clearly identifies and numbers each drilled shaft for reference.

C. Concrete Reinforcement: Provide submittals in accordance with the requirements of Section 03 20 00, Concrete Reinforcing.

D. Qualifications of Welders and Welding Procedures: Provide submittals in accordance with requirements of Section 03 20 00, Concrete Reinforcing, for reinforcing steel, and with requirements of Section 05 05 22, Metal Welding, for casing steel.

E. Portland Cement Concrete: Provide submittals in accordance with the requirements of Section 03 05 15, Portland Cement Concrete, and Section 03 30 00, Cast-in-Place Concrete.

1. Include submittal for tremie concrete equipment and placement method.
2. Include details of concrete mix design and test results of both a trial mix and a slump loss test. The test shall be conducted by an approved testing laboratory using approved methods to demonstrate that the concrete meets slump loss requirements.

F. Drilling Equipment: Submit description of equipment including cranes, power rating, torque, downward thrust, type, and size of drilling tools, final cleaning equipment, slurry pumps, core sampling equipment, tremies or concrete pump, and casings to be used.

G. Temporary Casing: If casings are proposed or required, submit description of casing dimensions, detailed procedures for installation and removal of casing, methods for advancing casing, means to be utilized for excavation of shaft with casing in-place, maintaining shaft reinforcement in proper alignment and location, and maintaining concrete slump to keep concrete workable during casing extraction.

H. Slurry: For shafts constructed by the slurry method using mineral or polymer slurry as required herein, submit description of procedures for mixing, using, maintaining, and disposing of slurry. Submit a proposed slurry mix design including a detailed plan for quality control of the slurry.

I. Shop Drawings: Submit Shop Drawings showing the following information. Include written explanation as necessary to describe proposed methods:

1. Methods and equipment proposed for load testing of drilled shafts including the load test reaction frame submittal prepared and stamped by a Registered Civil Engineer in the State of California
2. Details of shaft excavation method, including methods of removing obstructions such as boulders, concrete, steel, and timber
3. Details of methods to clean the shaft excavation
4. Details of reinforcing cage and structural steel section placement, including support and centralization methods
5. Where the dimensions of the shaft reinforcement do not permit inspection pipes to be placed as specified, submit pipe placement plan.

J. Product Data: Submit product data for coating agent proposed to facilitate lifting and removal of steel casing during placement of concrete.

K. Mitigation Plan: Submit plan for repair, supplementation, or replacement for each rejected drilled shaft.

L. Records and Reports: Submit daily reports and shaft record reports or logs as required by ADSC Standards and Specifications, using ADSC formats for forms.

1. Submit details of non-destructive testing such as gamma-gamma logging and crosshole sonic logging (CSL), if required, including testing and reporting the test data.

M. Testing Procedures: Submit the following information regarding testing procedures:

1. Details of quality control testing as specified in this Section.

1.6 QUALITY ASSURANCE

A. Construction Standards: Drilled shaft foundations shall be constructed in accordance with applicable requirements of ACI 336.1 and ADSC Standards and Specifications.

B. When special inspections are required under the California Building Code, Chapters 17 and 17A, as applicable, make arrangements through the Contracting Officer with Authority-hired inspection agency and ensure that inspections are performed.

PART 2 - PRODUCTS

2.1 DESIGN CRITERIA

A. Drilled shaft foundations shall consist of monolithically cast-in-place concrete piles.

B. Shaft foundations shall be straight cylindrical shaft type as indicated.

C. Shaft foundations shall extend from the concrete cutoff elevation to the tip elevation indicated on the Construction Drawings.

2.2 MATERIALS

A. Concrete Reinforcement: Conform with applicable requirements of Section 03 20 00, Concrete Reinforcing, of grades and sizes indicated.

B. Concrete: Conform with applicable requirements of Section 03 30 00, Cast-in-Place Concrete, and Section 03 05 15, Portland Cement Concrete. Provide class of concrete as required to resist all imposed loads. The minimum class of concrete shall be Class 3000 concrete.

1. Prepare separate mix designs for each class of concrete.
2. Slump for concrete: Slump shall be 5 inches, plus or minus 1 inch, for dry shafts without temporary casing, and 7 inches, plus or minus 1 inch, for dry shafts with temporary casing. Slump shall be 8 inches, plus or minus 1 inch, for wet shafts constructed with slurry displacement methods and concrete placed by tremie methods.

C. Steel Casing:

1. Where earth wall of drilled shaft is determined to be unstable or has a tendency to slough, crumble, or fall away, provide temporary steel casing to stabilize the shaft wall.

2. Inside diameter of the casing shall be the full diameter of the drilled shaft foundation as indicated, plus or minus 1/2 inch.
3. Steel casing shall have adequate strength and stiffness to withstand the pressure of concrete placement and earth and/or water pressure without distortion.
4. Inside surfaces of steel casing shall be smooth, clean, free from hardened concrete, and coated to facilitate easy lifting and removal during placement of concrete. If coated, the coating agent shall be submitted for approval prior to use.

D. Slurry: Use only mineral or polymer slurries in the drilling process unless the Contractor's geotechnical engineer approves in writing other drilling fluids. Water to mix slurry shall be obtained from sources compatible with the slurry material and accepted by the slurry manufacturer's representative and the Contractor's geotechnical engineer. Slurry properties shall meet those outlined in the following table, unless approved by the Contractor's geotechnical engineer in writing.

Required Slurry Properties		
Item to be measured	Range of results at 68°F (20°C)	Test methods
1. Density in lb/ft^3 (kg/m^3) before concreting for slurry 1 ft (300 mm) from pier bottom		(Mud balance) ASTM D4380
a. Mineral slurries (bentonite/attapulgite)		
1) No end bearing	85 max (1.4 x 10^3)	
2) With end bearing	70 max (1.0 x 10^3)	
b. Polymer slurry		
3) No end bearing	64 max (1.0 x 10^3)	
4) With end bearing	64 max (1.0 x 10^3)	
2. Marsh Funnel viscosity for entry, s/qt (s/L)*		(Marsh Funnel) API – RP13B – Section 2
a. Bentonite/attapulgite	26 to 50	
b. Polymer slurry	40 to 90*	
3. Sand content in slurry, immediately before concreting, 1 ft (300 mm) from bottom, by volume, %		(Sand screen set) ASTM D4381
a. Mineral slurries (bentonite/attapulgite)		
1) With end bearing	4 max	
2) No end bearing	20 max	
b. Polymer slurry		
1) No end bearing	1 max	
2) With end bearing	1 max	
4. pH during excavation	7 to 12	ASTM D4972

2.3 INSPECTION PIPES

A. Inspection pipes for gamma-gamma logging shall consist of Schedule 40 PVC pipe with a nominal inside diameter of 2 inches. Inspection pipes shall have a round, regular inside surface free of defects and obstructions, including all pipe joints, in order to permit free, unobstructed passage of probes to the bottom of the pipes. The inspection pipes shall be watertight and free of deleterious material on the outside that can prevent bonding with the concrete.

B. Cap each inspection pipe at the bottom and extend it from 3 feet above the pile cutoff down to the bottom of the reinforcing cage. Provide a temporary top cap or similar means to keep the pipes clean before testing. If the pile cutoff is below the ground surface or working platform, extend the inspection pipes to 3 feet above the ground surface or working platform. Provide approved covers or railings and locate inspection pipes as necessary to minimize exposure of testing personnel to potential falling hazards.

C. Place inspection pipes radially around the drilled shaft at a uniform spacing of not exceeding 33 inches measured along the circles passing through the centers of the inspection pipes. A minimum of two inspection pipes shall be used. The inspection pipe shall be placed at a minimum of 3 inches clear of the vertical reinforcement.

   1. Where the dimensions of the shaft reinforcement do not permit inspection pipes to be placed as specified, submit a plan for pipe placement for approval in the Shaft Placement Plan with a request for deviation. Obtain approval of pipe placement plan before fabricating shaft reinforcement.

D. Grout used for filling inspection pipes shall conform to the requirements of Section 03 62 00, Non-Shrink Grouting. The grout shall have strength properties equivalent to or better than those of the drilled shaft concrete.

E. Miniature Shaft Inspection Device (Min-SID): Provide a system that uses a stainless steel inspection “bell” equipped with a high-resolution digital video camera and a bank of LED lights to visually inspect the bottom of a drilled shaft.

PART 3 - EXECUTION

3.1 TOLERANCES:

A. Maximum variation of the center of any shaft foundation from the required location: 3 inches in the horizontal plane at the plan elevation for the top of the shaft

B. Maximum bottom diameter: minus zero, plus 6 inches, measured in any direction

C. Maximum variation from plumb: 1 (Horizontal):100 (Vertical)

D. Maximum bottom level tolerance: plus or minus 2 inches

E. Top elevation of the shaft: plus 1 inch or minus 3 inches from the plan top-of-shaft elevation

F. Only drilled shaft excavations and completed shafts constructed within the required tolerances shall be acceptable. Correct out-of-tolerance drilled shaft excavations using method or methods approved by the Contractor’s geotechnical engineer in writing.

3.2 METHOD TEST SHAFTS

A. Demonstrate the adequacy of methods and equipment proposed to be employed for construction of production shafts by successfully constructing method test shafts in accordance with those requirements set forth in the CHSTP Design Criteria. An acceptance test (refer to “Nondestructive Evaluation” specified in this Section) shall also be performed in method test shafts. Load testing consisting of compression load tests, tension load tests, and lateral load tests shall be performed on the method test shafts. In this case, construction of the method test shafts shall include drilling, placement of reinforcing steel, thread bars, and concrete. Otherwise, after completing drilling of the method test shaft, the test shaft shall be filled with unreinforced concrete in the same manner that production shafts will be constructed.

B. Method test shafts shall not be used as production piers.

C. Position method test shafts away from the production drilled shafts in a location approved by the Contractor’s geotechnical engineer in writing. Drill method test shafts to the depth of the deepest and the diameter of the largest diameter production drilled shaft indicated on the Construction Drawings.

D. Measure concrete volume during construction of the method test shafts.

E. Borehole caliper measurements shall be taken for the test shafts. Sonic borehole caliper, which remotely senses the borehole wall from a suspended probe, shall be used to determine the actual test shaft dimensions (i.e., shaft diameter with depth).

F. Once approval has been given to construct production drilled shafts, no change shall be permitted in the methods or equipment used to construct the satisfactory method test shaft without the written approval of the Contractor’s geotechnical engineer.

G. Unless otherwise shown in the Construction Drawings, the method test shafts shall be cut off 3 feet below finished grade and left in place. The disturbed areas at the sites of the test shaft holes shall be restored as nearly as practical to their original condition.

3.3 LOAD TESTS

A. Requirements:

1. Load test using conventional static load tests and Osterberg load cells shall be carried out on the method test shafts as described hereinafter to determine whether or not the shafts can carry and withstand the imposed loads.
2. Perform load tests for method test shafts (static and lateral loading tests) per site as defined in the CHSTP Design Criteria
3. Perform additional load tests as required by the Contractor’s geotechnical engineer. Except for shafts required for testing, additional shaft construction for the same structure shall not be permitted until the load tests are completed and the results of the load tests have been reviewed by and are satisfactory to the Contractor’s geotechnical engineer and accepted by the Contracting Officer.
4. Provide all labor, equipment, and apparatus as required to conduct the tests.
5. Install, remove, relocate, and reinstall weights and components as necessary to perform and complete the tests.

6. Conduct tests as soon as practicable after the concrete in each drilled shaft has attained the specified 28-day compressive strength, but not until at least 10 days have elapsed after placing the concrete.

B. Compression Load Tests: Perform tests in accordance with ASTM D1143. Method of load test shall follow "Quick Load Test Method for Individual Piles" as specified in ASTM D1143, Section 5.6. The test load shall be twice the service load for production shafts and the ultimate load for method test shafts. , Test loads may be greater when prescribed by the Contractor's geotechnical engineer,. Apply the load in increments equal to 10 percent of the test load, with a constant time interval between increments of 5 minutes. Maintain the test load for not less than 15 minutes, unless the shaft has failed as determined by the Contractor's geotechnical engineer. Remove the test load in increments equal to 25 percent of the test load, with a constant time interval between increments of 5 minutes.

C. Tension Load Tests: Perform tests in accordance with ASTM D3689. Method of load test shall follow "Quick Load Test Method for Individual Piles" as specified in ASTM D3689, Section 7.7. The maximum test load shall be twice the service load, or greater, as prescribed by the Contractor's geotechnical engineer. Apply the load in increments equal to 10 percent of the maximum test load, with a constant time interval between increments of 5 minutes. Maintain the maximum test load for not less than 15 minutes, unless the shaft has failed as determined by the Contractor's geotechnical engineer. Remove the test load in increments equal to 25 percent of the maximum test load, with a constant time interval between increments of 5 minutes.

D. Lateral Load Tests: Tests shall be performed in accordance with ASTM D3966. Method of load test shall follow "Standard Loading Procedures" as specified in ASTM D3966, Section 6.1.

E. The Osterberg Loadcell Testing: Tests shall be performed by Loadtest, Inc. in general compliance with ASTM D1143 Standard Test Method for Piles Under Static Axial Load using the Quick Load Test Method for Individual Piles. There is no known equal to Osterberg Loadcell Testing performed by Loadtest. The Contractor may perform testing by conventional methods as an alternative to Osterberg Loadcell Testing,

1. Regarding Osterberg Loadcell Testing, initially the loads shall be applied in increments equaling 5 percent of the anticipated ultimate capacity of the method test shaft. The magnitude of the load increments shall be proposed by Loadtest Inc. and approved by the Contractor's geotechnical engineer. Once approved, the load increments shall not be changed during the test.

3.4 EXCAVATION

A. General:

1. Excavate for shaft foundations by drilling or by other methods, as approved by method test shafts, to advance the excavation to the required bottom elevation. Avoid over-excavation. Excavation shall be performed through whatever materials are encountered to the dimensions, depths, and tolerances indicated. Bottoms of excavations shall be level and flat, and cleaned of loose material.
2. When required by the Contractor's geotechnical engineer, drill and core an exploratory hole, approximately 3 to 4 inches in diameter, to a depth of 15 feet below the excavation invert and backfill with grout.
3. Notify the Contractor's geotechnical engineer immediately when ground water is encountered.

4. Protect excavated walls with temporary steel casing and/or slurry as necessary, and as specified herein, to prevent cave-ins, displacement of the surrounding earth, water incursion, injury to personnel, and damage from construction operations. Maintain indicated neat lines of excavation for cased areas. Casings shall not be left in place unless otherwise specified by the Contractor's geotechnical engineer.
5. Make bottom surfaces level within the tolerances specified herein. Remove loose material, debris, and muck from bottom of shaft excavation to the tolerances and using the methods as specified herein.
6. Drill cuttings shall be the property of the Contractor and shall be disposed of in conformance with the provisions of Section 31 05 00, Common Works Results for Earthwork.

B. Dry Method of Construction:

1. Maintain sidewall stability of drilled shaft excavation and remove free water from excavation. Temporary casing specified under this Article in Paragraph entitled "Temporary Casing Method of Construction" may also be used with the dry method.
2. If water enters the excavation at a rate of greater than 12 inches per hour or more than 3 inches of water remains present in the bottom of the shaft excavation prior to concreting, the slurry method of construction (as specified herein) shall apply.

C. Slurry Method of Construction:

1. The slurry method of construction shall apply under the following circumstances: Once water begins to enter the drilled shaft excavation at a rate of greater than 12 inches per hour or if more than 3 inches of water remains present in the bottom of the shaft excavation. When the slurry method of construction applies, use slurry as specified herein to maintain a stable excavation during drilling and placement of reinforcing steel and concrete. Temporary casing, discussed below, may also be used with the slurry method.
2. Control of groundwater and maintenance of a stable, suitable drilled shaft excavation shall be achieved by use of drilling mud composed of mineral or polymer slurries as specified herein and permitted by the Contractor's geotechnical engineer. Set temporary surface casing to contain the slurry, as-needed, unless otherwise specified by the Contractor's geotechnical engineer.
3. Where drilled shafts are installed below groundwater or in caving soils, maintain the slurry level in the excavation not less than 5 feet above the groundwater level to maintain a stable hole. Maintain the slurry level above any unstable/caving zones a sufficient distance to prevent caving or sloughing of these zones.
4. The in-hole slurry shall meet the specified properties as given in the table included under the Article entitled "Materials" in the paragraph "Slurry" in this Section prior to concreting. Recycling of slurry is permitted provided that the recycled slurry satisfies the specified requirements. Clean, recirculate, remove sand from, or replace the slurry to maintain the required properties.
5. At completion of excavation and also before start of concrete placement, clean the drilled shaft bottom with an air-lift, recirculation system, or a cleanout bucket equipped with a one-way flap gate that prevents soil in the bucket from re-entering the excavation.

D. Temporary Casing Method of Construction:

1. Temporary steel casings with or without slurry, as specified herein and permitted by the Contractor's geotechnical engineer, may also be used to achieve control of groundwater and

maintenance of a stable, suitable drilled shaft excavation. Conduct casing installation and removal operations such that the adjacent soil outside the casing and drilled shaft excavation for the full height of the shaft is not disturbed. The diameter of the excavation shall be large enough to accommodate the casing while minimizing any void space outside the casing. Casings shall not be left in place unless otherwise specified by the Contractor's geotechnical engineer.

2. If the Contractor is utilizing casing that is adequately sealed into competent soils such that water cannot enter the drilled shaft excavation, with approval of the Contractor's geotechnical engineer, the excavation may continue in soils below the water table provided the water level within the casing does not rise or exhibit flow.
3. At completion of excavation and also before start of concrete placement, clean the drilled shaft bottom with an air-lift, recirculation system, or a cleanout bucket equipped with a one-way flap gate that prevents soil in the bucket from re-entering the excavation.

3.5 INSTALLATION OF STEEL REINFORCEMENT

A. Where it is not practicable to deliver the cage assembly to the jobsite as a complete unit ready for installation, make the remaining connections or splices, as indicated on the approved Shop Drawings, at grade prior to lowering the assembly into the hole. Provide sufficient internal bracing to keep the cage assembly intact and in shape during lifting and placing in the drilled hole.

B. Lower reinforcing steel into the hole in such a manner as to prevent damage to the walls. Secure the reinforcing steel symmetrically about the axis of the shaft such that it will not be dislodged during concrete placement. Use centering devices, securely attached to the cage, to clear the shaft walls and to maintain the cage in place throughout the concrete placement.

C. If after placement of the reinforcing steel and before placement of concrete, caving or sloughing of the drilled shaft excavation occurs such that the excavation walls or bearing surface is degraded, as determined by the Contractor's geotechnical engineer, remove reinforcement, stabilize excavation, and clean bottom of hole. Proceed with re-installation of reinforcement following stabilization and cleaning.

3.6 CONCRETE PLACEMENT

A. Place concrete in dry excavations whenever practicable. Use all practicable means to obtain a dry and stable excavation before and during concrete placement.

B. Concrete placed in dry holes shall not be permitted to free fall from a height greater than 8 feet without the use of adjustable-length pipes or tubes unless the flow of concrete is directed into the center of the hole using a hopper and not allowed to strike the reinforcement, reinforcement bracing, and other objects in the hole. Discharge concrete into the hopper at a continuous and rapid rate. Any break in the placement of the concrete shall be the basis for rejection of the drilled shaft.

C. For drilled shafts excavated and constructed by the slurry method using slurry, concrete shall be placed using tremie methods as specified herein. Start concrete placement only after a concrete supply adequate to fill the excavation has been assured. Place concrete within the time limit during which the excavation remains stable and the concrete maintains the specified slump. During concrete placement, the displaced slurry shall be pumped to holding tanks. Do not spill onto or contaminate the site. Do not use excavated slurry pits.

D. Tremie placement of concrete shall be performed in accordance with the requirements of ACI 336.1, Section 3.7.5, and as approved by the Contractor’s geotechnical engineer.

E. Vibration of the concrete shall not be required except in the top 30 feet of the drilled shaft.

3.7 WITHDRAWAL OF TEMPORARY STEEL CASING

A. Where temporary steel casings are used to support the excavation walls, withdraw the casing as the concrete is being placed, unless otherwise indicated or unless the Contractor’s geotechnical engineer requires that the casing be permanently grouted in place. Remove the steel casing in such a manner so that the lower edge of the steel liner will always remain a minimum of 5 feet below the surface of the concrete as placed to prevent water from entering the casing from the bottom. Extract casing at a slow, uniform rate with the pull in line with the shaft axis. Casing shall be withdrawn in such a manner that the concrete and reinforcing steel will not be damaged. Vibrate concrete during withdrawal of the steel casing.

3.8 FIELD QUALITY CONTROL

A. Inspections and Tests: The Contractor shall perform inspections and tests of concrete as specified in Section 03 05 15, Portland Cement Concrete.

B. Inspection of Shaft Excavations:

1. The Contractor’s geotechnical engineer shall provide inspection of the drilled shaft construction. At the completion of the Work, the Contractor’s geotechnical engineer shall determine the acceptability of the shaft installation within the terms and conditions of the Contract Documents and the Contractor’s geotechnical engineer’s construction engineering decisions.
2. The Contractor shall provide equipment for checking the dimensions and alignment of each shaft excavation. Dimensions and alignment shall be determined by the Contractor’s geotechnical engineer. Final shaft depths shall be measured with an appropriate weighted tape measure or other approved method after final cleaning.
3. All loose materials shall be removed by cleaning the shaft bottoms at completion of drilling. Shaft cleanliness shall be determined by the Contractor’s geotechnical engineer by visual inspection using a Mini-SID. If end bearing is not considered in the design of the capacity of the drilled shaft, the requirement of the shaft cleanliness using Mini-SID shall be waived.

C. Nondestructive Evaluations: Perform nondestructive evaluation consisting of gamma-gamma logging on all drilled shafts 24 inches in diameter or larger, including test method shafts and production shafts. This will serve as the acceptance test of the concrete.

1. Perform gamma-gamma logging tests in accordance with Caltrans California Test 233.
2. Conduct no operations within 25 feet of the gamma-gamma logging operations.
3. The Contractor’s geotechnical engineer shall perform additional tests if necessary to further evaluate the drilled shaft. These tests may include crosshole sonic logging and other means of inspection.

D. Concrete volume: Measure concrete volume during construction of the test method and production shafts.

E. Borehole caliper: Use a modern sonic caliper to determine the actual production shaft dimensions at the following frequency.

Diameter of Drilled Shaft	Frequency
Smaller than or equal to 24 inches	None
More than 24 inches and less than 72 inches	One every 4 drilled shafts
More than 72 inches to 96 inches	One every 2 drilled shafts
More than 96 inches	On all drilled shafts

F. Gamma-Gamma Logging: Perform a gamma-gamma logging in the presence of the Contractor’s geotechnical engineer. This serves to evaluate the homogeneity of the placed concrete. The Contractor’s geotechnical engineer shall determine the homogeneity of the placed concrete based on the requirements set forth in Caltrans California Test 233, Part 5C.

G. Records and Reports: Keep a record, on an approved form, for each drilled shaft foundation installed. Record on the form the location, dimensions, elevations of top and bottom, depth of stratum penetration, condition of bottom of excavation, concrete placement data, a continuous record of actual concrete volume placed versus theoretical volume, and any other data called for on the approved report form or pertinent to the foundation.

3.9 ACCEPTANCE AND REJECTION OF DRILLED SHAFTS

A. Upon completion of the field testing, the Contactor’s geotechnical engineer shall review all available drilling logs, drilled shaft construction logs, concreting logs, inspection reports, load test results, and nondestructive test results, if applicable, to determine the acceptability of the drilled shaft as specified herein.

1. If any test denotes less than the stated performance, the test results shall be immediately forwarded to the Contracting Officer.

B. If the Contractor’s geotechnical engineer or the Contracting Officer determines the available data is inconclusive, perform additional testing, coring, or other appropriate actions necessary for evaluating the acceptability of the drilled shaft.

C. If the additional testing confirms the presence of anomalies in the drilled shaft, the drilled shaft shall be rejected. The Contractor shall submit a Mitigation Plan prepared by the Contractor’s geotechnical engineer detailing the proposed repair, supplementation, or replacement of the rejected drilled shaft. Obtain the Contracting Officer’s acceptance of the Mitigation Plan prior to performing the mitigation.

D. Construct no production drilled shafts before the acceptance of the method test shafts by the Contractor’s geotechnical engineer.

END OF SECTION

SECTION 32 11 23

AGGREGATE BASE COURSES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Aggregate subbase material.

B. Aggregate base material.

C. Installation standards.

D. Spreading of material.

E. Compacting.

F. Field quality control.

1.2 REFERENCE STANDARDS

A. State of California, Department of Transportation (Caltrans), Standard Specifications:

1. Section 25 Aggregate Subbases
2. Section 26 Aggregate Bases

1.3 SUBMITTALS

A. Product Data: Submit source, gradation, R-value, sand equivalent, and durability for the proposed material.

B. Certified Test Results: At least seven calendar days in advance of desired date of Contractor's engineer's approval, submit certified test results performed by an independent testing laboratory certifying that the proposed base material complies with the specifications. Test results shall not be more than 30 days old. Test results shall indicate type of aggregate, gradation, R-value, sand equivalent, and, for aggregate base, durability.

C. Documentation: Submit delivery tickets from each load delivered to the Worksite which include, as a minimum the supplier, material and its composition, and material weight.

PART 2 - PRODUCTS

2.1 SUBBASE MATERIAL

A. Subbase shall be in accordance with Section 25, Aggregate Subbases, Caltrans Standard Specifications, Class 1, 2, or 3, as indicated.

2.2 AGGREGATE BASE MATERIAL

A. Aggregate base shall be in accordance with Section 26, Aggregate Bases, Caltrans Standard Specifications, Class 2.

2.3 SOURCE QUALITY CONTROL

A. Once the material has been approved, change source of supply only after obtaining approval of the new source material.

B. Approval of a source of supply does not relieve the Contractor from the obligation to furnish material which conforms to the specified requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Inspect in accordance with the Contractor’s Quality Management Plan and document in writing acceptance of the prepared subgrade or subbase, as applicable, before proceeding with the placement of aggregate course.

B. The subgrade or subbase to receive aggregate course, immediately prior to spreading, shall conform to the compaction and elevation tolerances indicated for the material involved and shall be free of standing water and loose or extraneous material.

3.2 INSTALLATION STANDARDS

A. Aggregate subbase course shall be applied over the prepared subgrade and compacted in accordance with Section 25 of the Caltrans Standard Specifications.

B. Aggregate base course shall be applied over the prepared subgrade or subbase and compacted in accordance with Section 26 of the Caltrans Standard Specifications.

C. Aggregate course shall have minimum uniform thickness after compaction of dimensions indicated. Where not indicated, compacted thickness shall be 6 inches.

D. Compaction expressed in percentages in this Section refers to the maximum dry density as determined by ASTM D1557.

3.3 MAINTENANCE

A. Maintain aggregate bases for pavement in specified conditions until succeeding pavement course is placed.

3.4 FIELD QUALITY CONTROL

A. Field testing shall be performed in accordance with the test methods specified in Caltrans Standard Specifications Sections 25 and 26. Tests shall be performed by Contractor-hired independent testing laboratory.

B. Perform sampling and tests of the aggregate subbase and base materials for grading, sand equivalent, resistance (R-value), and, for aggregate base, durability to determine compliance with

specified requirements. Samples shall be taken from material as delivered to the site. Tests shall represent no more than 500 cubic yards of base course material or one day's production, whichever is the lesser amount.

C. Perform field tests to determine compliance with requirements for compaction and moisture content of aggregate bases. Testing frequency shall be not less than one test for every 2,000 square feet of subbase and base course material, per layer or lift.

D. Measure thickness of the aggregate bases. Perform a minimum of one test for each unit of 2000 square yards of aggregate bases installed at a location selected by the Contracting Officer. For units of aggregate base less than 2000 square yards, perform a minimum of one test. In that unit where the base is deficient by more than 1/2 inch in thickness, the deficiency shall be corrected to meet the required grade and thickness using a method approved by the Contractor's engineer.

END OF SECTION

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SECTION 32 31 13

CHAIN LINK FENCES AND GATES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Fencing and gate materials.

B. Concrete.

C. Fence and gate installation.

D. Electrical grounding.

1.2 REFERENCE STANDARDS

A. ASTM International (ASTM):

1.	ASTM A53	Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
2.	ASTM A121	Specification for Metallic-Coated Carbon Steel Barbed Wire
3.	ASTM A123	Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
4.	ASTM A153	Specification for Zinc-Coating ((Hot-Dip) on Iron and Steel Hardware
5.	ASTM A392	Specification for Zinc-Coated Steel Chain-Link Fence Fabric
6.	ASTM A491	Specification for Aluminum-Coated Steel Chain-Link Fence Fabric
7.	ASTM A653	Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
8.	ASTM A752	Specification for General Requirements for Wire Rods and Coarse Round Wire, Alloy Steel
9.	ASTM A780	Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
10.	ASTM A824	Specification for Metallic-Coated Steel Marcelled Tension Wire for Use with Chain Link Fence
11.	ASTM B117	Practice for Operating Salt Spray (Fog) Testing
12.	ASTM F567	Practice for Installation of Chain-Link Fence
13.	ASTM F626	Specification for Fence Fittings
14.	ASTM F668	Specification for Polyvinyl Chloride (PVC) and Other Organic Polymer-Coated Steel Chain-Link Fence Fabric
15.	ASTM F900	Specification for Industrial and Commercial Swing Gates
16.	ASTM F934	Specification for Standard Colors for Polymer Coated Chain- Link Fence Materials
17.	ASTM F1043	Standard Specification for Strength and Protective Coatings on Steel Industrial Chain Link Fence Framework
18.	ASTM F1083	Specification for Pipe, Steel, Hot-Dipped Zinc-Coated (Galvanized) Welded, for Fence Structures

19. ASTM F1664 Standard Specification for Poly(Vinyl Chloride) (PVC) and Other Conforming Organic Polymer-Coated Steel Tension Wire Used with Chain-Link Fence

B. Chain Link Fence Manufacturers Institute (CLFMI):

1. WLG2445 Wind Load Guide for the Selection of Line Post and Line Post Spacing,

C. Federal Specifications:

1. RR-F-191/3 Fencing, Wire and Post, Metal (Chain Link Fence Posts, Top Rails, and Braces) (Detail Specification)

1.3 SUBMITTALS

A. Product Data: Submit manufacturer's product data and specifications of the specified chain link fencing and gates.

B. Shop Drawings: Submit detailed Shop Drawings of the fences and gates layout, including installation details of the fencing, posts, gates, hardware, and accessories for review. Include attachment details where post is secured to bridge railing or other barrier.

C. Design Submittals: For fences which are over eight feet high, fences with curved posts, and fences with solid panels, submit calculations for line post, line post spacing, footings, attachment detail where post is secured to bridge railing or other barrier, and attachment detail where solid panel is attached to fence. Calculations shall take into account at minimum, size and type of fabric, material strength and spacing of posts, soil type, and wind pressure. Attachment details and calculations shall also take into account future solid panel. Calculations shall be prepared and sealed by a professional engineer registered in the State of California.

D. Samples: If polymer-coated fencing is required or proposed, submit manufacturer's color chart of available colors for selection and physical sample of selected color.

1.4 QUALITY ASSURANCE

A. If curved post fencing as part of the Work: Construct full-size mockup of curved post fencing with solid panels and concrete wall, if applicable, with two posts spaced a minimum of 6 feet apart for Contractor's engineer's approval and for Contracting Officer's acceptance.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Requirements: Fencing shall include fabric covering, framework, barbed wire and supporting arms, concrete footings, gates, hardware, and all appurtenances and accessories as required for a complete installation.

B. The pipe sizes and strengths are minimum sizes for fences with fence fabric heights up to eight feet. Provide pipe sizes, strength, and spacing as required by fence height, mesh size, wire gauge, location, icing, wind conditions, and presence of solid panel where occurs. Verify post size and spacing using FS RR-F-191/3 and CLFMI WLG2445, taking into consideration the fence height, mesh size, wire gauge, presence of solid panel, location, icing, and expected wind gust.

C. Fence Fabric:

1. Fence Fabric Standard Size: No. 9 or No. 11-gauge chain link steel wire woven into 1-inch diamond mesh.
2. Type CL Fence Fabric: Zinc-coated steel fabric conforming to ASTM A392 with Class 2 coating.
    a. The Contractor may furnish aluminum-coated steel fence fabric conforming to ASTM A491, with 1-inch square mesh size fabricated from No. 9 or 11 gauge wire.

3. Type VCL Fence Fabric: Type CL fence fabric, PVC or polyolefin-coated in accordance with ASTM F668. Class 1, Class 2a, and Class 2b wire and fabric types are acceptable. Color shall be as designated in the Construction Specifications as specified in ASTM F934.
4. Selvages: Knuckle finish at top and bottom unless otherwise indicated.

D. Pipe Framework for Type CL Fencing: Round steel pipe and rail: ASTM F1043 Group IA Table 3 Heavy Industrial Fence Framework, Schedule 40 galvanized pipe per ASTM F1083. Exterior zinc coating Type A, interior zinc coating Type A. Regular Grade: Minimum steel yield strength of 30,000 psi.

1. End and Corner Posts: Minimum nominal outside diameter of 2.875 inches, weighing not less than 5.79 pounds per linear foot, for end, corner, and gate posts for gates 6 feet wide and smaller. Gate posts for gate leaves from 6 feet to 13 feet wide shall have minimum nominal outside diameter of 4.000 inches, weighing 9.11 pounds per linear foot.
2. Line Posts: Nominal outside diameter of 2.375 inches, weighing not less than 3.65 pounds per linear foot.
3. Rails and Braces: Nominal outside diameter of 1.660 inches, weighing not less than 2.27 pounds per linear foot. Posts shall include galvanized bolted fittings to properly secure rails and braces to posts.

E. Alternate Pipe Framework for Type CL Fencing: Round steel pipe and rail: ASTM F1043 Group IC Table 3 Heavy Industrial Fence Framework. Exterior zinc coating Type B, interior coating Type B or Type D.

1. End and Corner Posts: Minimum nominal outside diameter of 2.875 inches, weighing not less than 4.64 pounds per linear foot, for end, corner, and gate posts for gates 6 feet and smaller. Gate posts for gate leaves from 6 feet to 13 feet wide shall have minimum nominal outside diameter of 4.000 inches, weighing not less than 6.56 pounds per linear foot.
2. Line Posts: Nominal outside diameter of 2.375 inches, weighing not less than 3.12 pounds per linear foot.
3. Rails and Braces: Nominal outside diameter of 1.660 inches, weighing not less than 1.84 pounds per linear foot. Posts shall include galvanized bolted fittings to properly secure rails and braces to posts.

F. Pipe Framework for Type VCL Fencing: Polymer Coated Framework: Polymer coated framework shall have a PVC or polyolefin coating fused and adhered to the exterior zinc coating of the post or rail. PVC and polyolefin coatings shall have minimum thickness 10-mils (0.254 mm) per ASTM F1043. Color shall match fence fabric color. Sizes and weights shall be as specified for Type CL fence or alternate high-strength pipe framework.

G. Tension Wire:

1. Metallic Coated Steel Marcelled Tension Wire: No. 7 gauge steel wire, conforming to ASTM A824. Match coating type to that of chain link fabric.
2. Polymer Coated Steel Tension Wire: No. 7 gauge steel wire, conforming to ASTM F1664. Wire gauge specified in the core wire gauge. Match coating class and color to that of chain link fabric.

H. Post Caps and Fittings: Manufacturer's standard, pressed steel or malleable iron post caps, fittings, and accessories, meeting requirements of ASTM F626, galvanized after fabrication having a minimum zinc coating of 1.20 oz/sq. ft. Post caps shall be designed to fit securely over the posts to exclude water and to carry the top pipe rail and extension arms, where indicated. All other required fittings and hardware shall be provided to fasten to the pipe posts or concrete in the manner indicated.

1. Polymer Coated Color Fittings: Polymer coating minimum thickness 0.0006 in. fused and adhered to zinc coated fittings. Color to match fence system.

I. Truss Rods: Alloy steel rods conforming to ASTM A752, with minimum tensile strength of 80,000 psi, and minimum diameter of 5/8 inch. Provide rods with threaded ends and self-tightening galvanized turnbuckles and anchor plates. Secure anchor plates to posts and gate frames by welding.

J. Stretcher Bars: In compliance with ASTM F626, galvanized with a minimum zinc coating of 1.2 oz./ sq. ft. Provide one-piece lengths equal to full height of fabric with a minimum cross-section of 1/4 inch by 3/8 inch. Provide one stretcher bar for each gate and end post, and two for each corner and pull post.

K. Stretcher Bar Bands: Provide galvanized heavy pressed steel or malleable iron bands with a minimum cross section of 1/8 inch by 3/4 inch, spaced not over 15 inches on center, to secure stretcher bars to end, corner, pull, and gate posts.

L. Accessories: Provide miscellaneous materials and accessories, clips, tie wires (9-gauge), anchors, and fasteners as required for a complete installation. All items shall be galvanized in accordance with ASTM A123 or ASTM A153 as applicable, minimum zinc coating 1.20 oz/sq.ft. Accessories for polymer fencing shall match fence fabric coating.

M. Barbed Wire Extension Arms: In compliance with ASTM F626, pressed steel conforming to ASTM A653, hot-dip galvanized or galvannealed after fabrication, complete with provision for anchorage to end, corner, and pull posts and for attaching three rows of barbed wire to each arm. Arms shall be 45-degree angle or vertical as indicated, for three strands of barbed wire. Arms shall be integral with post top weather cap. Intermediate arms shall have hole for passage of top tension wire. Arms shall be capable of withstanding 300 pounds downward pull at outermost end of arm without failure.

1. Arms for Type VCL fencing: In compliance with ASTM F626. Polymer coating a minimum thickness of 0.006 fused and adhered to zinc coated fittings. Match color to fence system

N. Barbed Wire: Two-strand, zinc-coated, 12-1/2 gauge steel wire with 14-gauge, 4-point steel barbs spaced 5 inches apart, conforming to ASTM A121. Zinc coating shall be Class 3, 0.80 ounce per square foot for 12-1/2-gauge wire and 0.65 ounce per square foot for 14-gauge wire.

O. Gates: Gates shall be swinging type or sliding type as indicated, furnished complete with all hardware and accessories as required for a complete installation.

1. Gate Frames: Frames shall be fabricated from zinc-coated steel pipe members (to match posts in Type CL fencing) having a minimum outside diameter of 1.900 inches and weighing not less than 2.72 pounds per linear foot.
2. Fabrication: Conform to applicable requirements of ASTM F900, and the following:
   a. Assemble gate frames by welding. Match gate fabric to that of fence system. Install fabric with stretcher bars at vertical edges, and tie wires at top and bottom edges. Attach stretcher bars to gate frame at not more than 15 inches on center. Attach hardware with rivets or by other means that will provide security against removal or breakage.
   b. Provide additional horizontal and vertical members to ensure proper gate operation and for attachment of fabric, hardware, and accessories.
   c. Provide diagonal cross bracing consisting of minimum 1/2-inch diameter adjustable length truss rods on gates where necessary to provide frame rigidity without sag or twist.
   d. For Type VCL fencing, gate components shall be polymer-coated or painted in color matching fence fabric.
   e. Apply zinc-rich paint in accordance with ASTM A780 to welded joints.

3. Gate Hardware:
   a. Swinging Gates: Provide gate hinges, latch, stop, and keeper for each gate leaf, conforming to applicable requirements of ASTM F900. Fabricate positive locking gate latch of 5/16 inch thick by 1 3/4 inch pressed steel galvanized after fabrication. Provide latch with provision for locking gate with padlock. Provide galvanized malleable iron or heavy gauge pressed steel hinges.
   b. Sliding Gates: Provide manufacturer's standard rubber-tired rollers and roller track for floor-supported sliding gates. Include intermediate rollers or casters where required to prevent gate sag or deflection. Provide locking device and padlock eyes as part of latch for locking gate with padlock.

P. Pipe Sleeves: Pipe sleeves for fence post embedment in concrete curbs, barriers, and walls shall be fabricated from steel pipe conforming to ASTM A53 and galvanized in accordance with ASTM 123, sized to receive and support fence posts.

2.2 CONCRETE

A. Provide concrete footings for fence posts under this Section. The following shall be understood to be minimum requirements: Concrete for posts shall have a minimum compressive strength at 28 days of 3,000 psi, using 1-inch maximum size aggregate and five sacks of cement minimum per cubic yard, with a maximum slump of 4 inches. Concrete and grout materials, placing, and curing shall conform to the applicable requirements of Division 03, Concrete.

PART 3 - EXECUTION

3.1 PREPARATION

A. Installation of fencing shall not be started until final grading has been completed.

B. Locate and install fencing at the locations indicated.

C. Where posts are indicated or required to be embedded or set in concrete curbs, traffic barriers, or retaining walls, coordinate the installation of fencing closely with the installation of concrete as specified under Division 03, Concrete.

D. Furnish galvanized steel pipe sleeves for fence posts, as applicable, for installation in formwork at time required. Supervise installation of sleeves during formwork and placing of concrete to maintain exact dimensions according to template.

3.2 INSTALLATION

A. Install fencing and gates as indicated, in accordance with approved Shop Drawings, and applicable requirements of ASTM F567. Site fabricate as required to complete the fence installation.

B. Footing Sizes and Line Post Spacing: Footing sizes and line post spacing indicated on the Standard Drawings are minimums. Provide footing size and line point spacing as required by fence height, mesh size, wire gauge, location, icing, wind conditions, and presence of solid panel where occurs.

C. Posts shall be plumb and rigid after installation.

D. Drill holes for post footings in firm, undisturbed or compacted soil. Footing holes shall be not less than the sizes indicated on the Standard Drawings. Excavate deeper and construct deeper footings as required for adequate support in soft and loose soils, and for posts with heavy lateral loads.

E. Top rail: When specified, install 21 foot lengths of rail continuous thru the line post or barb arm loop top. Splice rail using top rail sleeves minimum 6 inch long. The rail shall be secured to the terminal post by a brace band and rail end. Bottom rail or intermediate rail shall be field cut and secured to the line posts using boulevard bands or rail ends and brace bands.

F. Terminal posts: End, corner, pull and gate posts shall be braced and trussed for fence six foot and higher and for fences six foot in height not having a top rail. Install horizontal brace rail and diagonal truss rod in accordance with ASTM F567.

G. Tension wire: Install tension wire four inch up from the bottom of the fabric. Fences without top rail shall have a tension wire installed 4 inch down from the top of the fabric. Tension wire to be stretched taut, independently and prior to the fabric, between the terminal posts and secured to the terminal post using a brace band. Secure the tension wire to the chain link fabric with a 9 gauge hog rings 18 inch on center and to each line post with a tie wire.

H. Where posts are indicated or required to be embedded or set in concrete curbs, traffic barriers, or retaining walls, grout or seal posts in sleeves as indicated.

I. Bolts: Carriage bolts used for fittings shall be installed with the head on the secure side of the fence. Peen over bolts to prevent removal of the nut.

J. Locate and install safety and restriction signs securely as indicated.

3.3 CHAIN LINK FABRIC INSTALLATION

A. Chain Link Fabric: Install fabric to outside of the framework. Attach fabric to the terminal post by threading the tension bar through the fabric; secure the tension bar to the terminal post with tension bands and 5/16 inch carriage bolts spaced no greater than 12 inches on center. Attach small mesh fabric less than 1 inch to terminal post by sandwiching the mesh between the post and a vertical 2 inch wide by 3/16 inch steel bar using carriage bolts, thru bolted thru the bar, mesh and post spaced 15 inch on center. Stretch chain link fabric taut, free of sag. Secure fabric to the line post with tie wires spaced no greater than 12 inches on center and to rail spaced no greater than 18 inches on center. Secure fabric to the tension wire with hog rings spaced no greater than 18 inches apart. Wrap tie wire around the post or rail and attached to the fabric wire picket on each side by twisting the tie wire around the fabric wire picket two full turns. Alternatively, wrap tie wire 360 degrees around the post or rail and the two ends twisted together three full turns. Cut off excess wire and bent over to prevent injury. Install fabric with maximum ground clearance of 2 inches.

3.4 BARBED WIRE INSTALLATION

A. Barbed Wire: Stretched taut between terminal posts and secured in the slots provided on the line post barb arms. Attach each strand of barbed wire to the terminal post using a brace band.

3.5 GATE INSTALLATION

A. Install gates and gateposts in compliance with ASTM F567, plumb, level, and secure for full opening without interference. Install ground-set items in concrete for anchorage as recommended by the fence manufacturer. Adjust hardware for smooth operation and lubricate.

B. Swing Gates: Install gates plumb in the closed position having a bottom clearance of 3 inch grade permitting. Hinge and latch offset opening space from the gate frame to the post shall be no greater than 3 inch in the closed position. Set double gate drop bar receivers in concrete footing minimum 6 inch diameter 24 inch deep. Install gate leaf holdbacks for all double gates.

C. Horizontal Slide Gates: Install according to manufacturer's instructions and in accordance with ASTM F567. Gates shall be plumb in the closed position, installed to slide smoothly with an initial pull force no greater than 40 lbs. Ground clearance shall be 3 inches, grade permitting.

3.6 CONCRETE

A. Handling and placing of concrete shall conform to the applicable requirements of Section 03 30 00, Cast-In-Place Concrete.

B. Place concrete around posts in a continuous pour. Check each post for plumb and vertical and top alignment, and hold in position during placement and finishing operations.

C. Trowel finish tops of footings, and slope or dome to direct water away from posts. Set keepers, stops, sleeves, tracks, eye bolts, and other accessories into concrete as required. Wheel rolling area for sliding gates shall be steel-trowel smooth finish concrete.

3.7 ELECTRICAL GROUNDING

A. Ground all fences and gates in accordance with CHSTP Design Criteria.

END OF SECTION

SECTION 32 90 00

PLANTING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Plant stock.

B. Excavation and backfill.

C. Soil preparation.

D. Herbicide application.

E. Rough and finish grading.

F. Planting of trees and shrubs.

G. Decomposed granite mulch.

H. Drainage test and auger holes.

I. Inspections.

J. Maintenance and plant establishment.

1.2 RELATED SECTIONS

A. Slope protection and hydroseeding are specified in Section 31 35 33, Turf and Hydroseed Slope Protection.

1.3 REFERENCE STANDARDS

A. American National Standards Institute (ANSI):

1. ANSI Z60.1 American Standard for Nursery Stock available from American Nursery & Landscape Association (www.anla.org)

1.4 SYSTEM DESCRIPTION

A. Soil used within landscaped areas shall be in a friable condition during transportation, placement, cultivation, and planting.

B. Friable in these Specifications refers to the structure and moisture content of soil. Friable soil shall be understood to mean soil that crumbles easily in the hand, does not stick to the hand, and does not form a ball when squeezed. Friable soil is not wet or muddy but is moist and damp. Obtain Contractor’s landscape architect’s determination of soil condition acceptability prior to installation and working of soils.

C. Soils in landscape areas that are worked when not friable shall be removed at the Contractor's expense and replaced with friable furnished topsoil complying with the specifications for topsoil herein.

1.5 SUBMITTALS

A. Soil Analysis Report: Submit a soil analysis report of the proposed salvaged or furnished topsoil from a California-licensed soil-testing laboratory. The Soil Analysis Report shall include the requirements specified in Article entitled "Soil Analysis Report" herein. Topsoil shall not be incorporated in the landscape planting work until the Contractor's landscape architect's has approved the Soil Analysis Report.

B. Product Data: Submit manufacturer's product data for the following items:

1. Root barrier.
2. Planting Accessories: Tree stakes, tree ties, and guy wire.
3. Fertilizer.
4. Lime.
5. Herbicides and pesticides.

C. Product Data for Toxicity: Submit California-licensed Pest Control Advisor's program and manufacturer's literature, including toxicity levels, for each pesticide and herbicide proposed for use in the landscape planting work.

D. Samples: Submit three samples and manufacturer's guaranteed analysis of the following items:

1. Salvaged and furnished topsoil, including source of topsoil.
2. Fertilizers, nitrogen stabilized organic amendment, and chemicals.
3. Top dressing.
4. Root barrier.
5. Landscape fabric.
6. Decomposed Granite Mulch.
7. Planting Accessories: Tree stakes, tree ties, and guy wire.

E. List of Plant Materials: Submit itemized list of plants including plant names and sizes with each delivery.

F. Inspection Certifications, As Applicable: Submit with each delivery.

G. Plant Substitutions: If plants are specified in the Contract Documents which formed a part of the Request for Proposals, plant substitutions will not be permitted unless the Contractor furnishes the Contracting Officer with written evidence from no less than three nurseries that the plants specified are not obtainable. Such evidence shall be submitted within 30 calendar days after the effective date of the Notice to Proceed. If Contractor's schedule allows sufficient time prior to planting of plants which are not readily available, Contractor shall contract for the growing of plants instead of proposing plant substitutions.

1.6 QUALITY ASSURANCE

A. Installer's Qualifications: Installer shall be a specialist in installing and planting landscape products, with a minimum of five years of documented experience in performing landscape work of comparable size, scope, and quality.

B. Supervision: Provide the services of at least one qualified person who shall be present at all times during execution of the work of this Section. That individual, who shall direct the work, shall be thoroughly familiar with the types of materials being installed and the proper methods for their installation.

C. Contractor’s Landscape Architect’s Observation:

1. Perform the following work only under the observation of the Contractor’s landscape architect:
   a. During preliminary grading and soil preparation;
   b. When shrubs and trees are spotted for planting, before planting holes are excavated;
   c. When finish grading has been completed, and before installation of plants; and
   d. When planting and other work has been completed.

2. Require the supervisor of the landscape planting work to be on the site at the time of each such observation.

1.7 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Delivery:

1. Deliver fertilizer and soil conditioner to the site in original unopened containers bearing manufacturer's guarantied chemical analysis, weight, manufacturer’s name, trademark, and conformance with state law.
2. Deliver plant materials to the jobsite no earlier than three calendar days prior to planting. Deliver plants with legible identification labels, as follows:
   a. Label trees, evergreens, bundles, or containers of like species or ground cover plants.
   b. State correct plant name and size indicated on the plant list.

3. Protect plant material during delivery to prevent damage to root ball or desiccation of leaves.
4. Transport plants in enclosed trucks. If trees are too large for enclosed trucks and are transported in open trucks, trees shall be wrapped to prevent damage and windburn. Adequate protection shall be placed between trees so that trunks are not scarred in transport and branches are not broken. Tree trunks shall be wrapped with protective covering prior to handling and loading. Covering shall be removed at the time of plant materials inspection at the job site.
5. Notify the Contractor’s landscape architect in advance of delivery of plant materials.

B. Handling: Exercise care in handling, loading, unloading, and storing of plant materials. Plant materials damaged in any way shall be discarded and replaced with undamaged materials.

C. Storage:

1. Protect plant materials from wind, excessive sun, and drying out.
2. Fertilizer and lime shall not be stored with any other landscape material.
3. Herbicides and pesticides shall not be stored with any other landscape material.

1.8 ENVIRONMENTAL REQUIREMENTS

A. Planting shall not be performed during weather conditions that may adversely affect landscape materials, plants, and planting conditions. No planting work, including plant pit excavation and preparation, shall be performed during periods of muddy or frozen soil conditions.

1.9 SITE CONDITIONS AND SCHEDULING

A. Landscape work shall not begin until structures, utilities, paving, and other improvements, which require access to or through planting areas, have been installed and approved in accordance with the Contractor's Quality Management System and accepted by the Contractor's landscape architect. Planting work shall not begin until the landscape irrigation system is installed in place, tested, and accepted by the Contractor's landscape architect.

1.10 WARRANTY

A. The following requirements supplement the General Provisions and Special Provisions Warranty requirements.

1. Warrant that trees, shrubs, groundcovers, and other plant materials will take root and grow vigorously within one year after final acceptance of plantings and throughout the Plant Establishment Period.
2. Corrective work for the purposes of the Warranty shall include removal and replacement of warranted plant materials which, for any reason, fail to meet the requirements of the Warranty. Replacements shall meet the same requirements as specified for the original materials, with the exception that size of replacement plant materials shall be in accordance with Caltrans Standard Specifications Section 20-9.03H, Replacement Plants. Replacements shall be warranted as required under the General Provisions and Special Provisions, for minimum of one year that shall start from the time the replacements are planted and accepted or until the end of the Warranty for the original planting, whichever is later.
3. The Warranty shall include replacement of trees and other plant materials that die back and lose the form and size as originally specified, even though they may have taken root and are growing after the die-back.
4. The Warranty shall include replacement of trees and other plant materials which are damaged by herbicide, diseased, dead, or which are in an unhealthy condition exhibiting weakness and the probability of dying.

PART 2 - PRODUCTS

2.1 PLANT STOCK

A. Plant stock and materials are indicated in the Planting List or Schedule on the Construction Drawings. Provide trees and plants of the varieties, sizes, and quantities indicated. Provide nursery-grown stock only, which is free from insect pests and diseases. All plant materials shall be in conformance with ANSI Z60.1.

B. Plants shall comply with federal and State laws requiring inspection for plant diseases and infestations. Inspection certificates required by law shall accompany each shipment of plants, and the certificates shall be submitted as specified under the Article entitled "Submittals" herein.

Plants shall be true to species, varieties, and the sizes indicated, and shall be labeled in accordance with the recommended practice of the American Nursery & Landscape Association.

C. Label trees and bundles, containers or flats of the same shrub, ground cover and vine with durable waterproof labels and weather resistant ink. Labels shall state the correct plant name and size as specified in the Plant List on the Construction Drawings, and shall be legible for 60 Days after delivery to the planting site. Plant material that is not labeled will be rejected.

D. Plants shall be healthy, shapely, and well-rooted. Roots shall show no evidence of having been root bound, restricted, or deformed. Plant material that has just been upgraded in container size shall be rejected. Root condition of plants in containers shall be inspected by the Contractor's landscape architect by removal of earth from the roots of not less than two plants of each species or variety from each source. If the sample plants inspected are found to be defective, the Contractor shall reject the entire lot or lots of plants represented by the defective samples.

E. Trees shall have straight trunks with the leader intact, undamaged, and uncut. Old abrasions and cuts shall be completely calloused over. Trees shall be measured when their branches are in their normal position. The height of a tree shall be measured in accordance with ANSI Z60.1. The width of a tree shall be measured at branching at the widest point. Sizes shown on the Construction Drawings are before pruning. Trees shall not be pruned prior to delivery except upon approval of the Contractor's landscape architect.

F. Trees shall be well tapered in the trunk so that when the nursery stake is removed, the tree supports itself upright without further staking. Trees shall have a main leader. The main branches shall be spaced vertically and alternately along the trunk. Branching shall not be concentrated in one location and there shall be no severe crossing of branches. Branches shall be smaller in diameter than the trunk. Branch attachments shall be free of embedded bark. Branching along the lower two-thirds of the trunk shall have at least one half of the foliage of the tree.

G. The major roots of deciduous and evergreen trees shall not be more than 2 inches below the top of their root ball. This measurement shall be made 4 inches from the tree's trunk at multiple locations around the root ball.

H. Rejected plant materials shall be removed from the site and replaced with materials that conform to specified requirements.

I. Plant material shall be grown under similar climatic conditions to those found at the project site.

J. Ground cover and vines shall be rooted plants, grown in flats unless indicated otherwise on the Construction Drawings, or approved by the Contractor's landscape architect.

2.2 TOPSOIL

A. Topsoil shall be obtained from sources within the site of the work, or shall consist of furnished topsoil obtained from sources outside the site, or from both such sources. Stripped site soil, if used as topsoil, shall meet the requirements specified herein.

B. Topsoil shall consist of fertile, friable soil of loamy character, and shall contain organic matter in amounts normal to the region. Furnished topsoil shall be obtained from well-drained arable and fertile agricultural land and shall be free from refuse, roots, heavy or stiff clay, stones larger than 1 inch in size, coarse sand, noxious seeds, sticks, brush, litter, grasses, weeds, toxic waste, and

other deleterious substances detrimental to the health of plants, animals, and humans. Furnished topsoil shall be capable of sustaining healthy plant life.

C. Topsoil shall have no inherent tendency towards compaction due to texture or soil structure or both as indicated in the soils analysis.

2.3 ORGANIC SOIL AMENDMENT

A. Soil amendment shall be nitrogen-stabilized sawdust. Use of treated, preserved, or painted wood products is not acceptable. Soil amendment shall be derived from a combination of fir and pine or cedar wood, free of weed seed, dust, and objectionable material, and containing the following physical properties:

Percent Passing	Sieve Size
95 - 100 percent	3/8 inch
90 - 95 percent	1/4 inch
85 - 90 percent	No. 8, 8 mesh
15 - 20 percent	No. 35, 32 mesh

B. Soil amendment shall contain the following chemical elements and compounds:

1.	Nitrogen Content (dry weight):	0.56 percent to 0.84 percent.
2.	Iron Content:	Minimum 0.08 percent diluted acid soluble Fe on a dry weight basis.
3.	Soluble Salts:	Maximum 4.0 millimohos centimeter at 25 degrees C as determined by the saturation extract method.
4.	Ash (dry weight):	0 to 8.0 percent.

2.4 FERTILIZER

A. Fertilizer shall be a commercial inorganic fertilizer in a granular and pelleted form. Fertilizer shall be delivered to the site in containers labeled in accordance with the applicable State of California, Department of Food and Agriculture regulations, bearing the warranty of the producer for the grade furnished. It shall be uniform in composition, dry, and free flowing. Provide fertilizer as follows:

1. Planted Areas: Pelleted type, with analysis of 6-20-20 (N-P-K), and granular type 16-6-8 (N-P-K).
2. Planting Holes: Tablets, 21-gram size, with an analysis of 20-10-5 (N-P-K).

2.5 HERBICIDES

A. Herbicides, including pre-emergent herbicide, shall be compatible with indicated plant materials. Proof of such compatibility shall be included in the pesticide and herbicide program submitted under Article entitled “Submittals” under “Product Data for Toxicity” herein.

B. The program shall specify the waiting period between spraying and planting.

C. Herbicides shall not sterilize the soil.

2.6 TOP DRESSING

A. Provide top dressing mulch as specified in the Construction Specifications.

2.7 BACKFILL

A. Backfill material for planting holes shall be topsoil or excavated soil that complies with topsoil specifications herein.

2.8 TREE STAKES AND TIES

A. Tree Stakes: 3-inch diameter by 10 feet, straight, close-grained, lodge pole pine, pointed at one end. Stakes shall be pointed prior to preservative pressure-treatment with copper napthanate that shall penetrate stake surfaces to a minimum depth of 1/4 inch.

B. Tree ties: Corded rubber tire strips - 1 inch wide by 1/4 inch to 1/2 inch thick by length as required. Strips shall not contain steel within or have wire tie ends.

C. Guy Wire: No. 12-gage galvanized soft steel wire.

2.9 ROOT BARRIERS

A. Provide commercially available manufactured root barriers, consisting of polyvinyl chloride or polypropylene sheeting having ultraviolet inhibitors and a minimum thickness of 0.085 inch. Barriers shall be either factory preformed into the circular shape shown, or have an integrated joining system for instant assembly into the final shape. Glued joints will not be acceptable.

B. Root barrier sheeting shall have horizontal tabs to prevent root growth from lifting the barrier. These tabs shall be spaced vertically not less than 8 inches on center, and horizontally not less than 8 inches on center. Depth of these tabs shall be not less than 3/8 inch at its widest point.

C. Root barrier sheeting shall have vertical fins running the full length on the inside face of the barrier at 90 degrees to the inside face, to direct root growth downwards. These fins shall be not less than 6 inches on centers, and its width shall be not less than 1/2 inch.

D. Sheeting shall have continuously reinforced top no less than 3/8 inch wide.

2.10 WATER

A. Potable or reclaimed water approved by jurisdictional authorities for landscape use.

B. Water for plants shall be obtained from fresh water sources and shall be free from injurious chemicals and other toxic substances harmful to plant life. The Contractor shall identify to the Contracting Officer all sources of water prior to use. The Contractor shall not use any water from any source which is found unacceptable by the Contracting Officer.

2.11 WATERING HOLES

A. Pipe for watering holes: Schedule 40 polyvinyl-chloride (PVC) pipe.

2.12 LANDSCAPE FABRIC

A. Geotechnical landscape filter fabric with ultraviolet ray protection. Landscape filter fabric shall provide soil stabilization and drainage through the fabric. Include steel or plastic soil-anchorage staples for holding fabric in place during the plant-establishment period.

2.13 DECOMPOSED GRANITE MULCH

A. Decomposed granite shall be crushed granite rock screenings, graded from 1/4-inch particles to dust, with uniform tan or buff color. Decomposed granite shall conform with the following aggregate gradation:

Sieve Size	% Passing
No. 4	95-100
No. 30	30-50
No. 200	5-15

2.14 VITAMIN B-1 SOLUTION

A. Provide vitamin B-1 solution for reducing shock to plants when transplanting.

2.15 SOURCE QUALITY CONTROL

A. The Contractor’s landscape architect shall inspect the source of supply (landscape nursery) of the proposed plant materials prior to shipment to the site.

B. Plant materials shall be properly labeled as herein before specified, before the Contractor’s landscape architect's inspection of proposed plant materials. Plant materials which do not conform to specified requirements shall be rejected, and shall be replaced with -plants approved by the Contractor’s landscape architect.

C. Notify the Contracting Officer at least 10 Days before shipment of plant materials from the source of supply.

2.16 SOIL ANALYSIS REPORT

A. Provide soil tests that include the following requirements:

1. Soil Fertility: Half-saturation percent, pH, salinity, nitrate, ammonium, phosphate, potassium, calcium, magnesium.
2. Agricultural Suitability: pH, salinity, boron, Sodium Absorption Ratio (SAR) using saturation paste extract.
3. Particle Size/Appraisal: pH, salinity, organic percent, USDA Particle size.
4. Germination (bio-assay) test.
5. Tendency towards compaction.

B. The Soil Analysis Report shall include a statement that the laboratory has reviewed the planting plan and the planting specifications, and that its recommendations respond to the specific needs of the Contract.

PART 3 - EXECUTION

3.1 COORDINATION

A. Coordinate layout and installation of plant materials with installation of the irrigation system to ensure that there will be complete and full irrigation coverage of the planted areas.

3.2 EXCAVATION AND BACKFILL

A. Excavate and backfill areas to be landscaped as indicated and specified herein.

B. Excavations for soil removal shall be to within 6 inches of back of curb or edge of walk. The Contractor shall be responsible for protecting and maintaining the integrity of compacted base rock and sub grade materials under paving and curbs, and for protecting all other structures in the excavated areas. Review with the Contractor’s landscape architect, the distance to remain away from other structures within the excavated areas. Do not undercut sides of excavation. Repair or replace damage to base rock, sub grade, paving, curbs or structures.

C. In landscaped areas that were previously paved, excavate to a minimum depth of 24 inches measured from the former pavement surface, but not less than 18 inches below the indicated finish grade.

D. In planting areas not previously paved, excavate the existing soil to a depth of 18 inches and remove from the site. Measurement of depth is from the top of the adjacent curb or paving.

E. Backfill excavated tree and shrub planting areas with topsoil. Prior to installing topsoil, scarify the bottom of the excavation to a 6-inch depth. Do not scarify or undercut sides of excavations. The Contractor shall be responsible for protecting base rock and sub grade compaction under adjacent paving and curbs. Provide topsoil backfill in 6-inch lifts. Incorporate the first 6-inch lift of topsoil into the existing soil at the bottom of the excavation.

F. Remove and dispose of asphalt debris, concrete, base rock, and existing soil in landscaped areas from the site. Refer to Section 31 05 00, Common Work Results for Earthwork, for requirements for disposal of surplus material from planting bed excavations.

3.3 ROUGH GRADING

A. Prior to planting, grade all areas to be landscaped. Fill as needed or remove surplus dirt and float areas to a smooth uniform grade. Slope all planting areas to drain. Roll, scarify, rake, and level as necessary to obtain true, even planting surfaces. Rough grading shall be inspected and approved by the Contractor’s landscape architect before any amendments and fertilizers are added.

B. Planting areas shall be thoroughly wetted down. Allow soil to dry so as to be workable, after which thoroughly cultivate to a depth of 6 inches using a rotary hoe.

C. Compact soil in planting beds to 75 percent relative compaction to prevent future settling.

3.4 SOIL PREPARATION

A. Soil Amendments, Fertilizers, and Cultivating:

1. Provide soil amendments, chemicals, and fertilizers specified herein for both furnished and approved on-site soils. These are minimum requirements. Provide such additional amendments and chemicals as are required by the Soil Reports.
2. Spread soil amendment and fertilizer evenly over all ground cover areas at the following rates:
   a. Soil Amendment: 6 cubic yards per 1,000 square feet.
   b. Fertilizer: 20 lbs. per 1,000 square feet of 6-20-20, (N-P-K).
3. After approval of amendment and fertilizer applications by the Contractor's landscape architect, incorporate soil amendments and fertilizers into the top 6 inches of soil by repeated rotary-hoe cultivation.

B. Watering: At completion of soil amendment and fertilizer installation, water the soil in all landscaped areas for a period of 14 Days. Maintain sufficient soil moisture at all times to induce weed seed germination, but not to saturate the soil. Soil shall be moist to a minimum depth of 24 inches. In locations where irrigation is by drip or bubblers, install a temporary irrigation system if necessary to keep the soil moist.

3.5 HERBICIDE AND PESTICIDE APPLICATION

A. General:

1. Before using herbicide or pesticide, obtain permits and approval from the jurisdictional authority for the proposed material and for the rate of application. In no case shall requirements for use of herbicide or pesticide be less restrictive than that spelled out in the accepted "California-licensed Pest Control Advisor's program".
2. The Contractor shall be responsible for protecting all plants, on or off the site, from damage by spraying operations.

B. Herbicide Application:

1. At the end of the watering period, spray the area with a herbicide listed for the application in the accepted California-licensed Pest Control Advisor's program. Refer to Article entitled "Submittals" herein.
2. Apply herbicide according to the manufacturer's written application instructions. Alternate weeding methods may be used upon approval of the Contractor's landscape architect.

C. Pre-Emergent Herbicide Application:

1. Pre-emergent herbicide shall be applied to all landscaped areas, including plant basins. Apply prior to mulching.
2. Pre-emergent herbicide shall be applied only when winds, if present, do not exceed 5 miles per hour.

3.6 FINISH GRADING

A. When weeding and soil conditioning have been completed and soil has been thoroughly water settled, landscaped areas shall be finish graded for placement of plant materials. Grading shall be performed when the soil is at optimum moisture content for working.

B. Finished grades shall be in accordance with the grading details for mounding in landscaped areas. All landscaped areas shall slope uniformly for positive drainage.

C. Grades not otherwise indicated shall be uniform levels or slopes between points where elevations are given, or between points established by walks, paving, curbs or catch basins. Finish grades shall be smooth, even, and on a uniform plane with no abrupt change of surface and no erosion scars.

D. Grading shall provide for natural runoff of water without low spots or pockets. Flow line grades shall be accurately set and shall be not less than 2 percent gradient unless otherwise indicated or approved by the Contractor's landscape architect.

E. Finish grade of earth in landscaped areas shall be one inch below the top of adjacent pavement, curbs or headers, with a gradual tapering away from these structures to a uniform depth of 3-1/2 inches below the top of adjacent pavement, curbs or headers, unless indicated otherwise on the Construction Drawings. Finish grade of earth shall be 3-1/2 inches below the top of pull and utility boxes or utility structures. Pull boxes and utility boxes shall be adjusted by raising or lowering to conform to grading requirements in landscaped areas.

F. Tops and toes of all slopes shall be rounded to produce a gradual and natural-appearing transition between relatively level areas and slopes.

G. Protect all areas against compaction by construction equipment.

3.7 PLANTING OF TREES AND SHRUBS

A. Plant materials shall be planted according to the schedules specified in the Construction Specifications.

B. Stake Plant Locations: Mark tree and shrub locations on site using stakes or similar means. Make adjustments to locations, where required by the Contractor's landscape architect, and obtain the Contractor's landscape architect's acceptance of locations before plant holes are dug.

C. Planting Holes: Dig pits with sloping sides as indicated. After pits are dug, loosen/scarify the bottom of the pit to a depth of 3 inches. Perform a drainage test, as specified in Article entitled "Drainage Test and Auger Holes" herein, where required. Do not excavate the planting holes deeper than identified in Paragraph "Placement of Plants" below.

D. Root Barriers: Install root barriers as indicated.

E. Watering Holes: Install watering holes as indicated.

F. Landscape Fabric: Install landscape filter fabric throughout landscaped areas, except where ground cover is to be installed. The fabric shall be tucked into the soil 2 inches along the perimeter of the landscaped areas. Provide 1-foot overlaps at sides and ends. Secure against

movement with specified anchorage staples. Furnish cutouts in the fabric to accommodate irrigation items and at tree, shrub, and vine planting locations.

G. Placement of Plants:

1. Do not handle container plants by the tops, stems, or trunks at any time. Lift plants so that the root ball is supported from the underside. Plants that do not have a satisfactory root system shall be rejected.
2. Cut the root ball vertically in a few places to encourage new feeder root development along the perimeter of the root ball, except as specified otherwise in the Construction Specifications.
3. Plant plants immediately after root balls are cut.
4. Place each plant in an upright and plumb position. Set plants with root balls at the height relative to finish grade as specified in the Construction Specifications or Drawings, as appropriate to plant size and species.
5. Ground cover shall be installed at spacings indicated on Construction Drawings, and shall be evenly spaced and staggered in rows. Place each plant in a pit so that the root system lies free without doubling and so that the roots are planted vertically. Firm the soil around each plant and water the area immediately to avoid drying out.

H. Fertilizing: Place fertilizer tablets in the following quantities around the perimeter of plant hole:

Plant Size	Qty. Fertilizer
1 gallon plant	1 tablet
5 gallon plant	3 tablets
15 gallon plant/B&B plant	5 tablets
24-inch box plant/B&B plant	7 tablets
36-inch box plant/B&B plant	9 tablets

I. Backfilling:

1. Backfill holes and pits with topsoil. Ensure that proper irrigation will be maintained to the root ball. Taper backfill around sides and up to the top of the root ball so that sides of the root ball are not exposed.
2. Backfill for planting in areas where topsoil has been placed earlier shall be topsoil excavated from the planting hole. Backfill for plants in areas where existing site soil remains shall be the topsoil amended in accordance with the soil report.
3. Construct a 4-inch high berm (watering basin) around plant holes and fill the watering basin with Vitamin B-1 solution. Mix and apply the B-1 solution in accordance with the manufacturer's written instructions.
4. Backfill shall be watered until the backfill material is moist to the full depth of the hole.

J. Pruning: Pruning shall not be performed unless specifically requested or approved by the Contractor’s landscape architect. Trees that are damaged due to improper pruning or wind damage shall be replaced.

K. Staking: Comply with the following where tree staking is indicated on the Construction Drawings.

1. Remove the nursery stakes and install specified tree stakes outside the root ball and one foot into undisturbed ground. Stakes shall not go through the root ball.

2. Ties shall be placed as low on the trunk as possible, but high enough so that the tree will return to the upright position after deflection.
3. Ties shall form a loose loop around the tree trunk and shall be staked so that the trunk cannot work towards the support stakes. Tree ties shall be secured in position in accordance with the manufacturer's recommendations.
4. Support stakes shall not be higher than 6 inches above the tie locations. A flexible auxiliary stake shall be attached to those trees needing extra trunk support as determined by the Contractor’s landscape architect.
5. Stake one tree of each size and obtain the Contractor’s landscape architect’s approval prior to staking remainder of trees.

L. Adjustment of Plants:

1. Plants that settle deeper than specified shall be raised to the correct level.
2. Plants that go out of plumb shall be straightened and re-staked.

M. Top Dressing: Install a 3-inch layer mulch in all landscaped areas. Mulch shall be kept away from stems and trunks of plants, and shall be kept off the foliage of ground cover. Install in tree watering basins.

3.8 DECOMPOSED GRANITE MULCH

A. Thoroughly blend decomposed granite mulch with organic binder material at a rate of 10 pounds of binder material per ton of crushed granite screenings. Blending shall be done with a cement mixer, pug mill, or similar equipment prior to placing and spreading the blended decomposed granite mulch over the hand-compacted backfill.

B. Place mulch in two 1-1/2-inch deep lifts compacted to a minimum 3-inch depth. Each lift shall be thoroughly moistened with water and then mechanically compacted to a minimum 85 percent relative density, with the finish surface of decomposed granite flush with surrounding curb and sidewalk.

C. Do not install decomposed granite mulch in tree watering basins.

3.9 DRAINAGE TEST AND AUGER HOLES

A. Requirements: After tree pits are dug and before planting operations, tree pits shall be water tested for drainage. One location per 80 square feet of tree pit shall be tested. In addition, test all tree pits in any area where a test tree pit does not drain within 24 hours, such as in hardpan areas, rocky ground, construction backfill, compacted areas, flat ground, low spots, and the like, in order to ensure that pits in those areas will drain properly.

B. Tests: Fill tree pits with water. Check holes after 24 hours to determine if water has drained out. If the water has not drained out, bring this to the attention of the Contractor’s landscape architect for remedial course of action. Adjust pit size, adjust of pit location, or add auger holes as required by the Contractor’s landscape architect if a drainage problem exists.

C. Auger Holes: If the Contractor’s landscape architect requires addition of auger hole when the plant hole that does not drain within the specified 24-hour period, auger hole for drainage as follows or as required by the Contractor’s landscape architect: Auger one 6-inch diameter hole through the bottom of excavated plant hole. Depth of the drill measured from the bottom of the excavation to the bottom of the drill hole shall be 4 feet. Backfill auger holes with 3/4-inch

diameter, well-graded drain rock up to bottom of the plant hole. Cover drain rock in the auger hole with a 2 feet by 2 feet piece of landscape filter fabric.

3.10 CLEANUP

A. Neatly dress and finish all landscaped areas.

B. Broom clean all pavements.

3.11 INSPECTION PRIOR TO COMMENCEMENT OF PLANT ESTABLISHMENT PERIOD

A. At completion of the work of this Section, request an inspection to determine the condition of landscaped areas. Following the acceptance of the condition of the landscaped areas by the Contracting Officer, the Plant Establishment Period shall commence.

B. Inspection shall be requested 2 working days in advance.

C. The Contractor and Contracting Officer shall be represented at the inspection.

D. Construction considered ready for inspection shall conform to the following requirements:

1. Landscape irrigation system shall be complete and operational.
2. Planting shall be healthy and free of infestations.
3. Landscaped areas shall be free of weeds.
4. Stakes and ties shall be as specified.
5. Mulch shall be raked to a uniform surface.
6. Debris shall be removed from the landscaped area, pavements shall be broom clean, and foliage shall be washed clean.
7. All plants shall be installed in place as indicated and specified.

3.12 NOT USED

3.13 PLANT ESTABLISHMENT

A. Plant Establishment Period shall extend through the end of the Warranty or for one year following the start of the Plant Establishment Period, whichever is later.

B. Maintain plant materials from the time of planting until the plant materials are well established and are exhibiting a vigorous growth. Maintenance shall continue until the end of the Plant Establishment Period.

C. Maintenance shall include watering, cultivating, weeding, re-mulching, repair of stakes, fertilizing, cultivation, spraying, and pruning as required to keep the plant material in a healthy growing condition and to keep the planted areas neat and attractive in appearance throughout the maintenance period. Maintenance shall also include treatment for fungus, diseases, rodents, insects, and repair of vandalism.

D. Each watering shall be of such quantity as to provide optimum growing conditions. Watering shall be controlled to prevent over saturation of soil leading to plant failure. Basins, where required, and basin walls shall be kept well formed. Rinse foliage of plant materials as often as necessary to keep foliage free of dust.

E. Trees, shrubs, and ground cover shall be maintained by regular watering, cultivating, and weeding. Stakes and ties shall be repaired as needed. Plants shall be sprayed for insect pests and pruned as necessary. Obtain the Contracting Officer or Contractor's landscape architect's written acceptance prior to pruning.

F. Rocks, clods, and debris that appear on the surface shall be removed. Heaved, settled, or eroded areas shall be restored by excavating, addition of topsoil, filling, finish grading, and rolling as required.

G. Gravel, surplus earth, papers, trash and debris, which accumulate in the landscaped areas and the areas directly adjacent to the paved areas, shall be removed and disposed of weekly. Such areas shall be cared for as required to present a neat and clean condition at all times.

H. Provide weeding as specified in Caltrans Standard Specifications, Section 20-9.03D, "Weed Control".

1. Weeds which appear in asphalt, concrete, or paved areas within Contract limits shall be killed before they exceed 2 inches in height or spread, by spraying with a contact herbicide, which shall not stain the surfacing.

I. Until the end of the Plant Establishment Period, replace plants as specified under Article entitled "Warranty".

3.14 PLANT ESTABLISHMENT FINAL INSPECTION AND ACCEPTANCE

A. This final inspection will be conducted at the end of the Plant Establishment Period.

B. Five days prior to the final inspection, 16-6-8 (N-P-K) granular form commercial fertilizer shall be applied to trees and shrubs, in the presence of the Contracting Officer, as follows:

Plant Size	Qty. Fertilizer
Specimen, 24-inch and larger	6 tablespoons
15-gallon	4 tablespoons
3- and 5-gallon	2 tablespoons
1- and 2-gallon	1 tablespoon
Ground cover and vines	6 pounds per 1,000 square feet

C. Care shall be taken to prevent the deposit of fertilizer on stems or leaves. Fertilizer shall be spread with a mechanical spreader wherever possible. Fertilizer shall be applied only during favorable weather conditions to prevent dissipation by wind. All plants shall be thoroughly watered after fertilizer has been applied.

D. Mulch shall be raked away from around plant bases. Fertilizer shall be spread around each plant base and worked into the top 2 inches of soil. Mulch shall then be replaced.

E. Prior to final inspection, weeding and a thorough cleaning of the landscaped areas shall have been performed. Unless otherwise acceptable to the Contracting Officer, remove tree stakes, tree ties, and guy wires and disposed of off-site.

F. The irrigation system, as applicable, shall be tested at the final inspection.

G. At the final inspection, the Contracting Officer will determine the condition of the plants and improvements. Acceptance of this work will be contingent upon proper maintenance and the establishment of vigorous plant materials. All plants, including replacement plants, shall be true to name and color, and shall be in a healthy, thriving condition, with foliage of normal density, size, and color. Any plants which fail to meet these requirements, or are dead, unhealthy, or missing, whether by disease, neglect, vandalism, or any other reason, shall be replaced. Replace plants within two weeks after final inspection and extend the Warranty (and Plant Establishment Period) as specified under Article entitled "Warranty".

END OF SECTION

SECTION 33 05 16

UTILITY STRUCTURES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Excavation and backfill.

B. Cast-in place concrete structures.

C. Precast concrete structures.

D. Metal components.

1.2 RELATED SECTIONS

A. Concrete formwork, concrete reinforcement, cast-in-place concrete, portland cement concrete, concrete repair and finishing, and precast concrete are specified in the various Sections under Division 03, Concrete.

B. Interior trench drains and gratings for interior uses are specified in Section 05 50 00, Metal Fabrications.

1.3 REFERENCE STANDARDS

A. ASTM International (ASTM):

1.	ASTM A36/A36M	Standard Specification for Carbon Structural Steel
2.	ASTM A48	Standard Specification for Gray Iron Castings
3.	ASTM A108	Standard Specification for Steel Bars, Carbon and Alloy, Cold-Finished
4.	ASTM A123	Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
5.	ASTM A153	Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
6.	ASTM A536	Standard Specifications for Ductile Iron Castings
7.	ASTM B26/B26M	Standard Specification for Aluminum-Alloy Sand Castings
8.	ASTM C33	Standard Specification for Concrete Aggregates
9.	ASTM C150	Standard Specification for Portland Cement
10.	ASTM C270	Standard Specification for Mortar for Unit Masonry
11.	ASTM C478	Standard Specification for Precast Reinforced Concrete Manhole Sections
12.	ASTM C618	Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
13.	ASTM C858	Standard Specification for Underground Precast Concrete Utility Structures
14.	ASTM C891	Standard Practice for Installation of Underground Precast Concrete Utility Structures

15. ASTM C1433 Standard Specification for Precast Reinforced Concrete Monolithic Box Sections for Culverts, Storm Drains, and Sewers

B. California Code of Regulations (CCR):

1. Title 24, Part 2, California Building Code, Chapter 21, Masonry, and State Chapter 21A, Masonry.

C. State of California, Department of Transportation (Caltrans):

1. Bridge Design Specifications Manual, Section 3, "Loads"

1.4 SUBMITTALS

A. Shop Drawings: Submit detailed drawings of cast-in-place and precast concrete utility structures and related metal work.

B. Product Data: Submit manufacturers' product data for standard manufactured precast concrete utility boxes and structures and for metal gratings and covers and other, related miscellaneous metal items.

C. Certification: Submit certification or other acceptable evidence that covers and grates to be provided for roadways and parking areas, including curb and gutter inlet grates, meet proof-testing requirements specified in this Section for H20 and HS20 loadings.

D. Third Party Utility Structures: Submit complete design package for non-Authority utility structures to the jurisdictional authority for approval.

PART 2 - PRODUCTS

2.1 GENERAL

A. Utility structures belonging to other jurisdictional authorities, including utility companies, shall be designed and constructed in accordance with standards and requirements of that utility company.

B. Covers and grates to be provided for roadways and parking areas, including curb and gutter inlet grates, shall meet proof-testing requirements for H20 and HS20 loadings in accordance with Caltrans Bridge Design Specifications Manual, Section 3.

C. Cover Designations: Precast Covers: Precast covers shall have the utility identification, such as "CHSRA Storm Drain", stamped into the cover. Refer to CHSTP Design Criteria for requirements of cover designations.

2.2 CAST-IN-PLACE CONCRETE STRUCTURES

A. Materials: Comply with requirements of Section 03 05 15, Portland Cement Concrete, except as specified otherwise herein.

1. Portland Cement: ASTM C150, Type II, low alkali.
2. Cementitious Admixture: Provide fly ash or pozzolan conforming to ASTM C618, Class F or N, not to exceed 15 percent by weight of the cement content.

3. Aggregates: ASTM C33, fine aggregate and Size Nos. 56 or 57 (1-inch maximum size) coarse aggregate.

B. Mix Design: Obtain design of concrete mix as specified in Section 03 05 15, Portland Cement Concrete, and incorporate the following requirements:

1. Concrete Strength: Class 4000 minimum in accordance with Table 03 0 15-A of Section 03 0515, Portland Cement Concrete, except that electrical structures, such as vaults, pull boxes, and concrete for ductbanks, shall be Class 3000.
2. Maximum water-cement plus pozzolan ratio: 0.45.
3. Maximum slump: 4 inches.

2.3 PRECAST CONCRETE STRUCTURES

A. General: The Contractor may provide precast concrete structures that conform to the general configuration, capacities, and inverts indicated.

B. Fabrication Standards: Comply with requirements of Section 03 40 00, Precast Concrete, and ASTM C478, ASTM C1433, and ASTM C858, as applicable, and applicable manufacturers' standards.

C. Materials: Concrete for sanitary sewer structures shall not deteriorate from chemical attack of sanitary waste.

D. Compressive Strength:

1. Minimum 4000 psi.
2. Concrete for electrical utility structures: Minimum 3000 psi.

2.4 METAL COVERS, GRATES, AND INLETS

A. Ferrous Castings:

1. Metal used in manufacturing of castings shall conform to ASTM A48, Class 35B for Gray Iron, or ASTM A536, Grade 65-45-12 for Ductile Iron.
2. Castings shall be of uniform quality, free from blowholes, shrinkage, distortion or other defects. Castings shall be smooth and cleaned by shotblasting.
3. Minimum tensile strength shall be 35,000 psi.
4. Castings shall be manufactured true to pattern; component parts shall fit together in a satisfactory manner. Round frames and covers shall have continuously machined bearing surfaces to prevent rocking and rattling.
5. Where castings will be subjected to loads of H20 or greater, as indicated, provide ductile iron castings.

B. Aluminum Castings: Where required to reduce weights of larger covers for ease of handling, such covers may be manufactured of aluminum castings conforming to ASTM B26/B26M, Alloy No. 713.0. Minimum tensile strength shall be 32,000 psi.

C. Manhole Covers: Provide cast, manufactured manhole covers and frames with heavy-duty solid cover (lid) or vented cover (lid) as indicated. Covers shall be embossed or engraved with nonslip diamond or square cross-hatched pattern. Provide covers with embossed or engraved word identification, as indicated or appropriate, for the enclosed or underground utility.

D. Grates:

1. Cast Ferrous Grates: Grates for area drains and catch basins shall be heavy-duty, bicycle-safe inlet grates and frames of size and configuration indicated.
2. Bar-Type Steel Grates: Refer to Section 05 50 00, Metal Fabrications, for requirements. Bar-type steel gratings will be permitted only in areas where vehicular traffic will not be encountered.

E. Curb and Gutter Inlets: Provide cast, manufactured curb inlet frame, grate, and curb box of size and configuration indicated. Curb and gutter inlets shall conform to the contour and profile of the concrete curb and gutter. Grates shall be heavy-duty and bicycle-safe.

F. Cast Iron Manhole and Inlet Steps: Provide cast, manufactured manhole and inlet steps with cross-hatched treads and with anchor configuration appropriate for cast-in-place concrete or precast concrete manholes and inlets as indicated. Provide steps for installation 12 inches on center in vertical alignment.

2.5 MISCELLANEOUS METAL

A. Requirements: Provide channel inserts, pulling eyes, ladders, and electrical grounding rods for electrical manholes and pull boxes as indicated.

B. Steel Materials: Standard structural sections, shapes, plates, bars, and rods, as indicated conforming to ASTM A36/A36M. Bars conforming to ASTM A108 will be acceptable.

C. Anchors and Bolts: Conform to requirements of Section 05 50 00, Metal Fabrications, as applicable. Bolts and studs, nuts, and washers shall be hot-dip galvanized in accordance with ASTM A153.

D. Ladders: Provide standard-manufactured or custom-fabricated steel ladders as required to meet the conditions indicated. Steel ladders shall be hot-dip galvanized after fabrication.

1. Refer to the CHSTP Design Criteria for grounding and bonding requirements.

E. Fabrication: Form and fabricate the work as indicated. Include anchors, fasteners, and accessories to anchor and secure the work in place.

F. Galvanizing: All ferrous metal items shall be galvanized after fabrication by the hot-dip process in accordance with ASTM A123. Weight of the zinc coating shall conform to the requirements specified under "Weight of Coating" in ASTM A123.

2.6 MORTAR

A. Cement mortar for the sealing of openings for pipe penetrations, for cementing of joints of component parts of precast structures, for providing of flow characteristics for the bottoms of drainage structures, and other features as indicated shall conform with the California Building Code, Chapter 21, Type S (without lime), with a minimum compressive strength at 28 days of 1,800 psi.

B. Mortar shall comply with applicable requirements of ASTM C270, including measurement, mixing, proportioning, and water retention. Ten percent by volume of the cement content of the mortar shall be fly ash or pozzolanic material conforming to ASTM C618.

C. Use mortar within the time specified by manufacturer but no later than within 90 minutes after mixing . Discard mortar that has been mixed longer or that has begun to set. Re-tempering of mortar shall not be permitted.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Excavation and Backfill: Provide excavation, prepared subgrade and aggregate base, and backfill as specified in Section 31 05 00, Common Work Results for Earthwork, Section 33 05 28, Trenching and Backfilling for Utilities, and Section 32 11 23, Aggregate Base Courses, as indicated.

B. Cast-in-Place Concrete Structures: Provide formwork, steel reinforcement, and concrete in accordance with applicable requirements of Section 03 11 00, Concrete Forming, Section 03 20 00, Concrete Reinforcing, and Section 03 30 00, Cast-In-Place Concrete.

C. Precast Concrete Structures: Comply with applicable requirements of ASTM C891.

D. Metal Components: accordance with the respective manufacturer's instructions. Covers and grates in roadways, parking areas, and concrete walks shall be installed flush with adjacent, abutting pavement.

3.2 UTILITY STRUCTURES (TO BE MAINTAINED BY OTHER JURISDICTIONAL AUTHORITIES)

A. Utility structures to be maintained by other jurisdictional authorities, such as utility companies, shall be designed and constructed in accordance with their standards and requirements.

B. Utility structures associated with services of or to be maintained by other jurisdictional authorities shall be inspected by the responsible entity having jurisdiction over the structure in accordance with its procedures. The Contractor shall coordinate with the Contracting Officer and the other jurisdictional authority, such as utility company, to schedule inspections.

3.3 FIELD QUALITY CONTROL

A. Perform field quality control as specified in Section 03 05 15, Portland Cement Concrete.

END OF SECTION

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SECTION 33 05 25

SUPPORT AND PROTECTION OF UTILITIES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Maintenance, support, and protection of existing utilities.

1.2 SUBMITTALS

A. Submit a copy of updated, verified list of names of the utility companies and their respective addresses and telephone numbers for information. Submit updates whenever the utility information changes.

B. Submit schedule of estimated shut-down times to jurisdictional authorities and obtain permission for shut-downs.

C. Submit schedule of approved shut-down times.

1.3 REQUIREMENTS

A. All existing utilities and their supporting facilities within construction limits that are not being relocated shall be protected in place in compliance with the requirements of their respective utility owner(s).

B. Below Grade Conditions and Concealed Conditions: Drawings and related documents may represent surface and subsurface conditions at the site and adjoining areas. These surface and subsurface conditions shall be compared with actual conditions before commencement of work.

C. Locate and document existing utilities from information obtained from utility owners and official county and municipal maps and records. In addition, locate and document any additional utilities through evidence such as pullboxes, handholes, catch basins, and poles. Maintain existing utilities and protect from damage as necessary to satisfy the requirements of jurisdictional utility companies and related codes and regulations.

D. Positive Location of Utilities: Prior to any excavation, provide proper notification to utility owners as stated in Article entitled " Required Notifications" herein to mark the location of their utilities. Each utility that requires support or protection during construction shall be positively located. Positive location of underground utilities shall be performed by potholing. Method of potholing shall be determined by the utility owner but in all cases potholing shall be performed by hand digging when excavating within 3 feet of an active utility.

E. Do not proceed with underground installations in vicinity of utilities that require support or protection until the utilities are properly exposed and protected to the satisfaction of the utility owners.

1. Immediately notify the utility owner and the Contracting Officer of conflicts in which there is less than 3 feet of separation between the existing and proposed facility.

F. Upon encountering existing facility which is not shown or upon ascertaining that facility differs from that shown, determine ownership, use, and disposition of such facility and proceed as follows:

1. If facility is abandoned or is to be abandoned, perform necessary work for either condition as specified.
2. If facility is to remain in service, perform support and restoration work in accordance with these specifications and the requirements of the utility owner.

G. Do not disconnect or shut down any part of the existing utilities and services, except by permission of the utility owner or jurisdictional authorities. Develop schedule of estimated shut-down times and obtain permission of utility owner or other jurisdictional authorities. Work with the utility owner and notify all interested parties, neighbors, utilities, and municipal and county authorities, as required.

H. Provide shoring, underpinning, and structural support for existing utility lines and structures that become suspended or otherwise unsupported because of adjacent excavation operations.

1.4 REQUIRED NOTIFICATIONS

A. Obtain markings by the affected utility companies identifying underground utilities and their locations 72 hours prior to performing any excavation or other work close to any underground pipeline, conduit, duct, wire, or other structure. Notify the utility owners before performing any such excavation work. Notify most affected utilities by calling Underground Service Alert (USA) at 1-800-642-2444 for Northern California and 1-800-422-4133 for Southern California. Contact utility owners that may not be covered by USA, such as owners of non-pressurized sewer lines, railroad companies, and Caltrans, by calling the affected utility owners directly. Keep markings current in accordance with the requirements of USA and other utility owners.

B. Protect active underground and overhead utility facilities from damage. If underground or aboveground utilities are damaged in any way, immediately notify affected utility owners for corrective action and notify the Contracting Officer.

1. The names of the utility companies in the area and their respective addresses and telephone numbers are listed in the Contract Documents for Contractor's information.
2. Develop a complete list including utilities identified by the Contractor. Contact the utility owners and update the list as required. Keep the list up-to-date throughout the Contract.

1.5 RELOCATION OF EXISTING UTILITIES

A. Refer to Section 33 05 33, Relocation of Existing Utilities.

PART 2 - PRODUCTS

Not used.

PART 3 - EXECUTION

3.1 GENERAL

A. Perform all work related to protection of existing utilities in conformance with the requirements of the utility owner and other jurisdictional authorities, as applicable. Comply with requirements related to location of the utility such as Authority requirements, including the CHSTP Design Criteria and Contract Documents, requirements of railroad companies, and Caltrans requirements, as applicable.

END OF SECTION

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SECTION 33 05 28

TRENCHING AND BACKFILLING FOR UTILITIES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Bedding and backfilling materials.

B. Detectable tape.

C. Staking and grades.

D. Existing utilities.

E. Trenching and excavating.

F. Bedding and backfilling.

G. Field quality control.

1.2 RELATED SECTIONS

A. Dewatering is specified in Section 31 23 19, Dewatering.

B. Excavation support systems are specified in Section 31 50 13, Temporary Excavation Support and Protection.

C. Earthwork is specified in Section 31 05 00, Common Work Results for Earthwork. The work of this Section shall conform to the requirements of Section 31 05 00, Common Work Results for Earthwork, as applicable.

D. Foundation drains and other subsurface drainage are specified in Section 33 46 00, Subdrainage.

1.3 REFERENCE STANDARDS

A. American Public Works Association (APWA):

1. APWA Uniform Color Code

B. ASTM International (ASTM):

1.	ASTM C33	Specification for Concrete Aggregates
2.	ASTM D882	Test Method for Tensile Properties of Thin Plastic Sheeting
3.	ASTM D2103	Specification for Polyethylene Film and Sheeting
4.	ASTM D2578	Test Method for Wetting Tension of Polyethylene and Polypropylene Films

C. State of California, Department of Transportation (Caltrans), Standard Specifications:

1.	Section 88	Geosynthetics.

D. State of California, Department of Transportation (Caltrans), Office of Structure Construction, "Trenching and Shoring" Manual.

1.4 DESCRIPTION

A. This Section includes specifications for excavating, trenching, and backfilling for utilities and related structures, as indicated, including underground piping for water supply, sanitary and storm sewerage piping; trackway and roadway site subsurface and drainage piping; underground electrical conduits and ductbanks; and utility boxes, catch basins, manholes, inlets, pull boxes, and vaults.

1. Trenching and backfilling for utilities includes restoration of existing pavements or any other existing improvements, where applicable, to the conditions existing before the excavation.

1.5 REGULATORY REQUIREMENTS

A. Regulatory requirements that govern the work of this Section include the following governing codes:

1. California Code of Regulations (CCR), Title 8, Chapter 4, Subchapter 4 — Construction Safety Orders, and Subchapter 19 — Trench Construction Safety Orders, for trench excavations of 5 feet or more in depth.
2. California Code of Regulations, Title 24, Part 2, California Building Code, Chapter 33, and Appendix Chapter 33, Excavation and Grading, for protection of the public.

1.6 SUBMITTALS

A. Refer to Section 31 50 13, Temporary Excavation Support and Protection, for requirements to submit drawings and supporting calculations for trench excavation support systems for excavations of 5 feet or more in depth

PART 2 - PRODUCTS

2.1 BEDDING AND BACKFILLING MATERIALS

A. Bedding:

1. Sand: Sand for bedding of pipe in utility trenches shall be a clean and graded, washed sand, all passing a No. 4 U.S. Standard sieve, and conforming generally to ASTM C33 for fine aggregate. Finer sand may be used, if convenient, provided the sand is clean and does not contain deleterious substances in excess of the amounts specified in ASTM C33, Table 3.
   a. Only sand will be permitted for bedding of concrete pipe, clay pipe, and cast-iron pipe.

2. Pea Gravel: Clean and graded, washed river-run gravel, ASTM C33, Size No. 7. Pea gravel may be used in trenches requiring additional drainage and for backfilling above the pipe's upper half (above the horizontal centerline).

B. Backfill Material: Backfill for excavations and trenches under structures, paving, or as indicated on the accepted Con shall be Structural Fill. (Refer to Section 31 05 00, Common Work Results for Earthwork, for requirements.) Common Fill, where not prohibited by local jurisdictional

requirements, will be permitted only for backfilling of excavations and trenches in open areas and landscaped areas.

C. Slurry Cement Backfill: Slurry cement backfill shall consist of a fluid, workable mixture of portland cement, clean and graded aggregate, and water.

2.2 ACCESSORIES

A. Filter Fabric: Geotextile engineering fabric conforming to Caltrans Standard Specifications, Section 88-1.02B, Filter Fabric, Class C.

B. Detectable Tape: Detectable underground utility marking tape, color-coded and identified with permanent text legend. Tape shall be laminate construction with top layer either clear film with reverse printing of color and text or pigmented film laminated to solid aluminum foil core and a clear protective film laminated to back of foil. Materials and inks shall not degrade when handled during installation or when exposed to acids, alkalis, and other destructive substances commonly found in soils. Tape shall be detectable utilizing inductive mode using a pipe and cable locator. Tape shall also comply with the requirements of the jurisdictional authority.

1. Tape shall comply with the following specifications:

Property	ASTM Test Method	Value
Thickness	D2103	5.0 mils
Thickness of Aluminum Foil Core	D2103	0.35 mils
Elongation	D882	80 percent minimum
Tensile Strength	D882	4,200 psi minimum
Printability	D2578	40 Dynes minimum

2. Colors: Comply with AWPA Uniform Color Code.
3. Legends: As required by jurisdictional authorities or as proposed by the Contractor and accepted by the Authority Representative.
4. Width: Tape width shall be as required by the jurisdictional authority with the following additional requirements:
   a. Width shall be no less than that recommended by the tape manufacturer for the burial depth of tape.
   b. Minimum width of tape shall be six inches, with the following exception: Tape identifying irrigation lines which is buried no deeper than 24 inches may be three inch wide.

5. Provide accessories for tape installation in accordance with the tape manufacturer's recommendations.

PART 3 - EXECUTION

3.1 STAKING AND GRADES

A. Refer to Section 31 05 00, Common Work Results for Earthwork, for requirements.

3.2 EXISTING UTILITIES

A. Refer to Section 33 05 25, Support and Protection of Utilities, and Section 31 05 00, Common Work Results for Earthwork, for requirements.

3.3 TRENCHING AND EXCAVATING

A. Comply with CCR, Title 8, Trench Construction Safety Orders, and the California Building Code, Chapter 33 and Appendix Chapter 33, as applicable.

B. Perform trenching and excavating as indicated and required for drainage and utility piping, conduits, and related structures, and provide shoring, bracing, pumping, and planking as required and as specified in Section 31 50 13, Temporary Excavation Support and Protection.

C. Excavate to the lines and grades indicated.

D. Excavate trenches for pipes and conduits by the open-cut method, except where tunneling or jacking are indicated or required by the jurisdictional authority, including other railroads. Hand-excavate for crossing pipelines.

E. In paved areas, cut pavement on the neat lines at the width indicated for the trench. Pavement shall be saw cut. After compacting the backfill, restore pavement to a condition equivalent to that existing at the start of construction or comply with the jurisdictional authority's requirements. Restore pavement damaged outside the neat lines.

   1. Where indicated or required by the governmental authority having jurisdiction, provide slurry cement backfill for trench excavation to underside of pavement.

F. Excavate trenches to the indicated width at all points below a horizontal plane 2 feet above the top of the pipe. Excavation above this plane may exceed the indicated width as required. Where the width is not indicated, make the width not less than 6 inches or more than 18 inches from the outside of the pipe. If the excavation exceeds permissible dimensions, install higher strength pipe or encase the pipe in Class 3000 concrete.

G. The bottoms of excavations shall be firm, undisturbed earth or cut sub grade, clean and free from loose material, debris, and foreign matter. When bottoms of excavations or trenches are a soft or unstable material, the bed shall be made firm and solid by removing said unstable material to a sufficient depth and replacing same with sand or pea gravel, compacted to at least 90 percent relative compaction.

H. Where water is encountered in the trench, dewater as specified in Section 31 23 19, Dewatering, and provide sand or pea gravel as required to drain the water and stabilize the bed.

I. Bell holes shall be accurately placed and shall not be larger than required to make the joint.

J. Excavations for structures shall conform to applicable requirements of Section 31 05 00, Common Work Results for Earthwork.

3.4 BEDDING AND BACKFILLING

A. Material for bedding of pipe shall be sand. Minimum thickness of sand bedding under concrete, clay, and cast-iron pipe shall be 2 inches. Provide firm and uniform support of piping at indicated elevations and grades. Tamp sand bedding as required for firm support.

1. The joints of gravity flow piping shall be wrapped with filter fabric all around the pipe. Place filter fabric under the pipe before laying pipe in sand bedding. Filter fabric shall extend at least 12 inches on each side of the joint.

B. Backfill below the horizontal centerline of pipe shall be sand. Backfill to 6 inches above the top of pipe from the horizontal centerline of pipe shall be either pea gravel or backfill material specified in Article entitled "Bedding and Backfilling Materials" herein.

C. Backfill shall be placed in 6-inch layers, leveled, rammed, and tamped in place. Each layer shall be compacted with suitable compaction equipment to at least 90 percent relative compaction, taking care not to damage or misalign any pipe. The top 12 inches under structures and pavement shall be compacted to at least 95 percent relative compaction.

D. Backfilling around concrete structures and for ductbanks and similar utilities shall conform to the applicable requirements of Section 31 05 00, Common Work Results for Earthwork.

E. Install tape according to manufacturer's recommended methods. Place detectable tape between one foot and 24 inches above new and recently exposed buried utilities, including conduits, fiber optics, communication and signal cables, gas lines, water lines, electrical lines, and other utilities, such as fuel lines.

3.5 FIELD QUALITY CONTROL:

A. Comply with applicable requirements specified in Section 31 05 00, Common Work Results for Earthwork.

END OF SECTION

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SECTION 33 05 33

RELOCATION OF EXISTING UTILITIES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Removal of existing utilities, relocation of existing utilities, and constructing new utilities to replace existing.

B. Coordination with jurisdictional authorities to obtain their records of existing utilities and for review and approval of design and construction of utilities to be relocated.

1.2 SUBMITTALS

A. Submit design of relocated utilities to jurisdictional authority and obtain its approval prior to submitting the design to the Contracting Officer for information.

B. Submit design of relocated utilities which have been approved by jurisdictional authority.

1.3 REQUIREMENTS

A. Design and installation of utilities to be relocated shall be per the requirements of the jurisdictional authority (typically the utility owner).

B. Coordinate the design of relocated utilities with jurisdictional authority.

C. Design and installation of the utilities within Authority right-of-way shall also meet the requirements of CHSTP Design Criteria and Section 33 05 25, Support and Protection of Utilities.

D. Perform the following work as specified Section 33 05 25, Support and Protection of Utilities, and the requirements of the jurisdictional authority (typically the utility owner):

1. Document utility owners with their contact information.
2. Locate and document existing utilities
3. Make notifications.
4. Scheduling shut-downs.
5. Support and protection of utilities shall be in accordance with the requirements of the jurisdictional authority, but shall comply, as a minimum, with the provisions of Section 33 05 25, Support and Protection of Utilities.

1.4 RELOCATION OF EXISTING UTILITIES BY OTHERS

A. If the Contract requirements indicate that certain utilities will be relocated by the respective utility companies prior to or during construction, coordinate with utility owners and confirm that either such relocations have taken place or when they will take place. Obtain record (“as-built”) documents of the relocated utilities and field-verify their locations prior to any excavation near existing and relocated utilities.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Materials and products shall be as required by the jurisdictional authority provided the casings and other materials for lines within Authority right-of-way meet or exceed those required under the CHSTP Design Criteria.

PART 3 - EXECUTION

3.1 GENERAL

A. Perform all work related to relocation of existing utilities and construction of utilities for other jurisdictional authorities, in conformance with the requirements of the utility owner and in compliance with requirements of other jurisdictional authorities, as applicable. Other applicable requirements may include Authority requirements, including the CHSTP Design Criteria and Contract Documents, requirements of other railroad or Caltrans, related to the location of the utility.

END OF SECTION

SECTION 33 11 00

WATER UTILITY DISTRIBUTION PIPING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Buried pipe and fitting.

B. Valves.

C. Fire hydrants.

D. Thrust blocks and harnessing.

E. Field quality control.

F. Test.

G. System disinfection.

H. Connections to existing mains.

1.2 RELATED SECTIONS

A. Trenching, bedding, and backfilling for pipelines are specified in Section 33 05 28, Trenching and Backfilling for Utilities.

1.3 REFERENCE STANDARDS

A. ASTM International (ASTM):

1.	ASTM A126	Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
2.	ASTM A197	Standard Specification for Cupola Malleable Iron
3.	ASTM A307	Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength
4.	ASTM D1784	Standard Specification for Rigid Poly (Vinyl Chloride) (PVC Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds
5.	ASTM D1785	Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
6.	ASTM D2466	Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
7.	ASTM D2564	Standard Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings
8.	ASTM D2855	Standard Practice for Making Solvent-Cemented Joints, with Poly (Vinyl Chloride) (PVC) Pipe and Fittings
9.	ASTM D3139	Standard Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals

10. ASTM F439 Standard Specification for Chlorinated Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
11. ASTM F477 Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe

B. American Water Works Association (AWWA):

1. AWWA C500 Metal-Seated Gate Valves for Water Supply Service
2. AWWA C502 Dry-Barrel Fire Hydrants
3. AWWA C651 Disinfecting Water Mains
4. AWWA C900 Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 in. through 12 in. for Water Transmission and Distribution

C. Manufacturers Standardization Society of the Valve and Fittings Industry (MSS)

1. MSS SP-70 Gray Iron Gate Valves, Flanged and Threaded Ends
2. MSS SP-80 Bronze Gate, Globe, Angle, and Check Valves
3. MSS SP-85 Gray Iron Globe & Angle Valves, Flanged and Threaded Ends

D. Water Utility District Standards: Note that all work shall be performed and completed in accordance with the jurisdictional water utility district's standard drawings and specifications. The Contractor shall be responsible for obtaining all such standards and for compliance with such standards as applicable.

E. Underwriters Laboratories Inc. (UL):

1. UL 246 Hydrant for Fire-Protection Service

1.4 SUBMITTALS

A. Submit respective manufacturer's product data for manufactured materials and equipment, including all valves and fire hydrants.

B. Submit Shop Drawings showing piping layout and pipe, valves, hydrants, and locations of tie-ins, buttresses, and thrust blocks.

1.5 SUBMITTALS FOR CLOSEOUT

A. Record Drawings: Record Drawings shall include actual location of piping mains, valves, connections, and invert elevations.

1.6 COORDINATION

A. Coordinate the installation of the water supply system with the jurisdictional water utility owner.

B. The Contractor shall make arrangements with the jurisdictional water utility district to provide water services to the water meters' points of connection for station facilities and landscape irrigation systems, other water lines, and modifications to existing water mains, as indicated on the Construction Drawings. The Contractor shall be responsible for making all such arrangements and paying for all costs including permits, fees, and services.

PART 2 - PRODUCTS

2.1 BURIED PIPE AND FITTINGS

A. Requirements: Provide the types, sizes, and configurations of pipe, fittings, and miscellaneous materials and installation accessories as indicated.

B. PVC Pipe and Fittings, 3 Inches and Smaller:

1. Pipe: Polyvinyl chloride (PVC), ASTM D1785, Schedule 40 or 80, as indicated, Type I, Grade 1.
2. Fittings: ASTM D2466, socket weld, same material and schedule as pipe, or meeting requirements of ASTM F439, as applicable.
3. Joints: Socket welded with PVC solvent cement conforming to ASTM D2564 and ASTM D2855.

C. PVC Pipe and Fittings, 4 Inches and Larger:

1. Pipe: AWWA C900, Class 200, polyvinyl chloride (PVC) water pipe with bell and spigot ends and flexible ring joints.
2. Fittings: ASTM D1784, Type 1, Grade 1, polyvinyl chloride (PVC) fittings, Class 200, or meeting requirements of ASTM F439, as applicable.
3. Joints: ASTM D3139, gasketed bell joints with ASTM F477 gaskets.

2.2 VALVES

A. Gate Valves:

1. Gate Valves up to 2-1/2 Inches: 150-pound bronze body, non-rising stem, single wedge, threaded connection.
2. Gate Valve 3 Inches and Over: AWWA C500, iron body, bronze trim, non-rising stem with square nut, single wedge, mechanical joint ends with type gland and serration’s designed for plastic pipe service.

B. Pressure Reducing Valves: MSS SP-80 valves, 2 inches and smaller, shall be all bronze construction meeting the requirements of MSS SP-80. MSS SP-85 valves, 2 1/2 inches and larger, shall be all cast iron construction meeting the requirements of MSS SP-70. Valves 2-1/2 inches and smaller shall have threaded connections. Valves 3 inches and larger shall have flanged connections. Valves shall be stainless steel spring-loaded, single-seated, and suitable for tight shutoff under dead end conditions. Provide with renewable stainless steel seat, nylon inserted diaphragm, and bolted spring chamber. Valves shall be rated for 300-psi working pressure, adjustable from 25 to 75 psi, factory set at 50 psi. Pressure gauges (or gauge ports) shall be installed upstream and downstream of pressure-reducing valve.

C. Backflow Preventer: Provide device approved by the jurisdictional water utility company. As a minimum, backflow preventer shall be a reduced pressure principle assembly with two rising stem gate shut-off valves, two resilient seat ball valve test cocks, and two replaceable resilient seat check valves. Backflow preventer shall be suitable for 175-psig operating pressure and 140 degrees F operating temperature. Backflow preventer shall be of bronze construction with screwed inlet and outlet for 3-inch and smaller sizes and cast iron epoxy-coated construction with 150-pound flanged inlet and outlet for 4-inch and larger sizes.

2.3 FIRE HYDRANTS

A. Provide fire hydrants and related appurtenances as indicated. Fire hydrants shall comply with the requirements of the jurisdictional authority and the standard drawings and specifications of the jurisdictional water utility district, as applicable.

B. Fire hydrants shall meet the requirements of AWWA C502 and UL 246, as applicable, and shall be wet barrel type, as a minimum, with a minimum of two discharge nozzles of size(s) required by the jurisdictional authority.

2.4 CONCRETE FOR THRUST BLOCKS

A. Provide Class 3000, 1-inch aggregate, concrete for all thrust blocks, as specified in Section 03 05 15, Portland Cement Concrete, with reinforcement where indicated.

2.5 MISCELLANEOUS METAL

A. Tie Rods: Stainless steel, Type 316, threaded ANSI standard, bolt threaded on both ends. Minimum 1/2-inch diameter for 4-inch pipe, 5/8-inch minimum diameter for 6-inch and 8-inch diameter pipe, and 3/4-inch minimum diameter for 12-inch and larger.

B. Rod Couplings: Malleable iron, ASTM A197, turnbuckle design, female threaded to mate with tie rods, 5/8-inch and 3/4-inch sizes to mate with both rods and mechanical joint bolts.

C. Pipe Clamps: For sizes 4 inches and larger, provide with malleable iron rod sockets. Provide washers in lieu of rod sockets where authorized, conforming with ASTM A126, Class A, cast iron. Bolts and bolting shall conform to ASTM A307.

PART 3 - EXECUTION

3.1 MAINTAINING WATER SERVICES

A. Maintain water service and conduct operations at times selected to minimize the duration and inconvenience of service interruption.

B. At least 24 hours prior to the required cutting or abandoning of an existing water main, notify the jurisdictional water utility owner, and obtain approval of the schedule. Actual cutting or abandoning of an existing water main shall be performed by the Contractor after receiving approval from the owner of the facility.

C. Keep existing water mains parallel to new water mains in service until new water mains are ready for service.

D. Where the existing water main or service is to be cut for connection to new piping, the work shall be performed by the Contractor. Initial work operations shall include the test pitting of all points of connection (tie-in) to ensure the true location of existing linework.

E. Water valves in service shall be operated only by personnel of the jurisdictional water utility owner.

F. Except as specified otherwise herein, construction methods shall be in accordance with the applicable provisions of the jurisdictional water utility owner's standard drawings and specifications.

3.2 INSTALLATION

A. Installation Requirements:

1. Excavations in which products will be buried shall be dry.
2. Excavate pipe trench in accordance with Section 33 05 28, Trenching and Backfilling for Utilities. Hand trim bottom of trench to approximately 6 inches below invert of pipe.
3. Top of pipe to finished grade shall be 30 inches unless otherwise indicated or approved by the Contractor's engineer.
4. Place sand bedding material, meeting the requirements of Section 33 05 28, Trenching and Backfilling for Utilities, at trench bottom, level in one continuous layer not exceeding 8 inches in compacted depth. Compact bedding to 95 percent relative density.
5. Backfill around sides and to 6 inches above pipe with cover fill tamped in place and compacted to 95 percent relative density.
6. Test pipe distribution system and place tracer wire on top of pipe as specified herein prior to covering pipe. Backfill trench in accordance with Section 33 05 28, Trenching and Backfilling for Utilities.
7. Maintain optimum moisture content of bedding material to attain required compaction density.
8. Provide concrete thrust blocks for elbows, tees, valves, and appurtenances of buried piping. Thrust blocks shall be constructed as indicated and in accordance with AWWA requirements.
9. Install piping true to line and grade, supported and guided to assure alignment under all conditions.
10. Install pipe to allow for expansion and contraction without stressing pipe or joints.
11. Install unions at each connection to valves, both sides of each valve.
12. Make change in line with fittings. Do not spring joints to effect change of direction.
13. Do not field cut pipe unless necessary. Make such necessary cuts by means of equipment designed for the purpose, ensuring a smooth and square end.
14. For connection to existing pipe, provide pipe with suitable ends or adapters, after verification of size and type of existing pipe.
15. Install tie rods and pipe clamps at every joint fitting and valve.

B. Valves:

1. Install valves in accordance with the valve manufacturer's installation instructions.
2. Where valves are provided by the jurisdictional water utility owner, provide suitable access for performance of such work.
3. Where necessary, alter the typical valve manhole to suit actual conditions. Alterations in valve manholes shall be operable from the street level. All operator nuts shall be plumb to the valve manholes.
4. Set valve on solid bearing.
5. Center and plumb valve box over valve. Set box cover flush with finished grade.

C. Fire Hydrants:

1. Provide fire hydrant installations as indicated. Installation shall conform to requirements of the jurisdictional fire department and the water utility owner's standard drawings and specifications.
2. Provide necessary appurtenances and accessories as required to complete the installation.
3. Paint hydrants in accordance with applicable requirements of the Construction Specifications, Division 09 Finishes.
4. Set hydrants plumb, locate pumper nozzle perpendicular to and facing roadway.

D. Thrust Blocks and Harnessing:

1. Provide for counteracting thrust caused by static and dynamic forces, including water hammer at bends, tees, reducers, valves, and dead ends by installing harnessing as indicated or required. For other methods, submit details for approval of the jurisdictional water utility owner prior to use.
2. Provide concrete thrust blocks as indicated where harnessing is not practicable.

E. Water Service Connections: Provide water service connections, where necessary, in accordance with the California Plumbing Code, the installation instructions of the service pipe and fittings manufacturer, and the utility company requirements with reduced pressure back-flow preventer and water meter with by-pass valves.

F. Acceptance Requirements: After installation of pipes, ends of pipes shall be either capped or plugged. No piping shall be buried before being inspected and tested.

3.3 FIELD QUALITY CONTROL

A. Compaction testing of related earthwork shall be performed in accordance with applicable requirements of Section 31 05 00, Common Work Results for Earthwork.

B. If tests indicate work does not meet specified requirements, remove such work, replace, and retest.

3.4 TESTS

A. Protection from Flooding: Provide positive measures to protect exposed, installed pipe and compacted pipe bedding from flooding during testing.

B. Notice of Testing:

1. Give 48 hours notice of intention of testing to the jurisdictional water utility owner, which will furnish, install, and operate pumps, gages, meters, and individual pipe connections to test openings.
2. Designate largest sections feasible for testing and sterilizing. Testing and sterilizing operations shall be performed by the Contractor at its expense.

C. Testing Requirements:

1. General:
   a. Prior to backfilling, isolate the system by use of approved valves, caps and plugs, or other acceptable methods.

b. Maintain such isolation throughout the performance of leakage and pressure testing.

c. Where valves are used for isolation, eliminate leakage through such valves if it occurs. Maintain new work isolated from existing water mains, except for test connections, until testing and sterilization have been completed.

2. Hydrostatic Tests:

a. For hydrostatic tests, provide approved caps and plugs in sections to be tested, and remove them after testing.

b. Prevent leakage in pipes and fittings at openings. Temporarily block plugged and capped ends to prevent displacement.

c. Install the water source connection for testing the isolated section. The Contractor's engineer may permit the use of a tap that will be furnished and installed by utility owner.

d. Provide labor and materials required for leakage testing, including excavation for installation and removal of pumps, gages, meters, and water source connections.

e. Where leakage exceeds the water utility company's standards, perform necessary corrective measures.

f. Remove and replace defective pipes, joints, fittings, valves, and other appurtenances. Reset such items if displaced.

g. Perform hydrostatic tests in accordance with the jurisdictional water utility district's requirements. All such tests shall be witnessed by the jurisdictional water utility district's representative. The Contractor shall be responsible for making all such arrangements.

h. Remove and replace defective pipe, joints, fittings, valves, and other appurtenances. Reset such items if displaced.

D. Testing and Flushing of Potable Water System: Test the potable water system hydrostatically in sections to a pressure of at least 150 psi for not less than 15 minutes, witnessed by the Contractor's engineer. Pressure test pipe before burial. Repair leaks and retest the system until the system is leak free. Use testing instruments calibrated by a qualified laboratory in accordance with the Contractor's Quality Management Plan. Test sequence shall be as follows:

1. Lines shall be fully flushed.
2. Lines shall be hydrostatically tested.
3. Lines shall be fully flushed.
4. Lines shall be fully disinfected.

3.5 SYSTEM DISINFECTION

A. Before final acceptance of the water supply system, each section of the new line shall be disinfected in accordance with AWWA C651. One of the following sources of disinfectant shall be used:

1. Mixture of water and chlorine gas;
2. Direct application of chlorine;
3. Mixture of water and calcium hypochlorite; or
4. Mixture of water and calcium chloride.

B. Before disinfecting, flush the line thoroughly to remove dirt and extraneous materials. Clean each section of the line between valves independently.

C. Retain the disinfectant solution in the pipe for at least 24 hours. Following this sterilization period, the residual chlorine content at the ends of the section and at other representative points shall be not less than five parts per million. Then, the line shall be drained and thoroughly flushed with water until the residual chlorine content is similar to that obtained from the existing water distribution system.

D. Take water samples and test in accordance with AWWA C651.

3.6 CONNECTIONS TO EXISTING MAINS

A. Following testing and sterilization, new water distribution lines shall be connected to existing mains as indicated. Each connection shall be made at a time and in a manner that will result in the least interruption of service.

B. All connections involving shut down of jurisdictional water utility's existing facilities shall be made under the immediate supervision of the jurisdictional water utility district. No member of the Contractor's forces may operate any valve controlling the flow of water in the water utility's existing system.

C. Provide tie-ins to the existing system at a time that is convenient to jurisdictional water utility district, which may be in the evenings and on weekends.

END OF SECTION

SECTION 33 40 00

STORM DRAINAGE UTILTIES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Storm Drainage Material.

B. Excavation and Bedding.

C. Laying Pipe.

D. Pipe Joint.

E. Backfilling.

F. Concrete Encasement.

1.2 RELATED SECTIONS

A. Trenching and backfilling for pipelines are specified in Section 33 05 28, Trenching and Backfilling for Utilities.

B. Catch basins, curb and gutter inlets, and manholes are specified in Section 33 05 16, Utility Structures.

C. Subsurface drainage system is specified in Section 33 46 00, Subdrainage.

1.3 REFERENCE STANDARDS

A. American Association of State Highway and Transportation Officials (AASHTO):

1.	AASHTO M36	Standard Specification Corrugated Steel Pipe, Metallic-Coated, for Sewers and Drains
2.	AASHTO M190	Standard Specification Bituminous Coated Corrugated Metal Culvert Pipe and Pipe Arches

B. ASTM International (ASTM):

1.	ASTM A760	Specification for, Corrugated Steel Pipe, Metallic-Coated for Sewers and Drains
2.	ASTM C12	Standard Practice for Installing Vitrified Clay Pipe Lines
3.	ASTM C14	Standard Specification for Nonreinforced Concrete Sewer, Storm Drain, and Culvert Pipe
4.	ASTM C76	Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
5.	ASTM C270	Specification for Mortar for Unit Masonry
6.	ASTM C425	Specification for Compression Joints for Vitrified Clay Pipe and Fittings

7.	ASTM C443	Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets
8.	ASTM C700	Specification for Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated
9.	ASTM C881	Specification for Epoxy-Resin-Base Bonding Systems for Concrete
10.	ASTM D2564	Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems
11.	ASTM D2665	Specification for Poly (Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings
12.	ASTM D2680	Specification for Acrylonitrille-Butadiene-Styrene (ABS) and Poly (Vinyl Chloride) (PVC) Composite Sewer Piping
13.	ASTM D2729	Specification for Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings
14.	ASTM D2855	Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings
15.	ASTM F477	Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe

C. California Code of Regulations, Title 24, Part 2, California Building Code, Chapter 21 and Chapter 21A, Masonry.

1.4 SUBMITTALS

A. Shop Drawings: Submit detailed drawings that indicate site drainage in plan and section, including relationship to other systems, interfaces, and drainage structures, connections, alignment, grade, bedding and backfill, and other pertinent data.

B. Product Data: Submit manufacturers' product data for pipe and pipe connection materials.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Pipe Connection Requirements: Ends of pipe shall be bell-and-spigot, grooved, shiplapped, or secured with couplings, collars, or other connection fittings to assure continuous alignment of pipe and leakproof joints.

B. Clay Pipe:

1. Pipe: ASTM C700, extra strength; for pipe 8 inches in diameter and under.
2. Joints and Gaskets: ASTM C425.

C. Concrete Pipe:

1. Plain Pipe: ASTM C14, Class 3; for pipe less than 12 inches in diameter.
2. Reinforced Pipe: ASTM C76, Class V; for pipe 12 inches in diameter and larger.
3. Joints and Gaskets: ASTM C443.
4. Cement for Concrete Pipe: ASTM C150, Type II.

D. Corrugated Metal Pipe: ASTM A760 or AASHTO M36, Type I pipe, bituminous coated in accordance with AASHTO M190. Furnish pipe complete with coupling bands and gaskets as required for watertight joints.

E. Plastic Pipe:

1. Pipe: PVC pipe conforming to ASTM D2665 or ASTM D2729 for pipe up to and including 6 inches in diameter, and ASTM D2680 or ASTM D2729 for pipe larger than 6 inches in diameter.
2. Provide fittings, such as adapters, couplings, tees and caps of same material as pipe.
3. Cement: ASTM D2564.
4. Gaskets: Rubber, ring type, ASTM F477.

F. Bonding Adhesive: Adhesive for bonding of mortar to concrete pipe and catch-basin and manhole openings shall be an epoxy-based bonding agent conforming to ASTM C881, Type V, tinted to show by visual inspection where it has been applied.

G. Bedding and Backfill Material: Refer to Section 33 05 28, Trenching and Backfilling for Utilities, and ASTM C12, for requirements.

2.2 MORTAR

A. Mortar for pipe joints, catch-basin openings, and other locations where indicated shall be Type S mortar in accordance with Chapter 21 of the California Building Code, with a minimum compressive strength at 28 days of 1,800 psi.

B. Mortar shall be job mixed in accordance with requirements of ASTM C270, including measurement, mixing, proportioning, and water retention.

C. Accurately measure mortar ingredients and mix a minimum of 3 minutes after water has been added, in a mechanical batch mixer, using sufficient water to produce a workable and plastic consistency. Hand mixing will be permitted for small quantities only.

D. Use mortar within 90 minutes after mixing. Discard mortar that has been mixed longer or that has begun to set. If necessary, mortar may be re-tempered within this time limit, by replacing water lost due to evaporation and by thorough remixing.

2.3 CONCRETE

A. Concrete for headwalls, ditch closures, and lining or paving of ditches shall conform with applicable requirements of Section 03 11 00, Concrete Forming, Section 03 20 00, Concrete Reinforcing, Section 03 15 00, Concrete Accessories, Section 03 30 00, Cast-in-Place Concrete, Section 03 05 15, Portland Cement Concrete, and Section 03 35 00, Concrete Finishing. Provide Class 3000 – 1-inch concrete unless otherwise indicated.

2.4 DRAINAGE STRUCTURES

A. Unless otherwise indicated, materials and fabrication specifications for drainage structures shall conform to section 33 05 16, Utility Structures, as applicable, and applicable manufacturer's standards.

PART 3 - EXECUTION

3.1 INSTALLATION OF PIPE

A. Excavation and Bedding:

1. Excavate trenches as specified in Section 33 05 28, Trenching and Backfilling for Utilities.
2. Bedding: Provide bedding as specified in Section 33 05 28, Trenching and Backfilling for Utilities. Classes of bedding are defined in ASTM C12. Use class of bedding indicated. Where pipe is to be encased in concrete, place concrete against undisturbed soil.

B. Laying Pipe:

1. Lay pipe to line and grade indicated. If pipe is of the bell-and-spigot type, lay bells in cross-cuts cut in trench. Lay pipe with the bell or grooved end uphill.
2. Install clay pipe in accordance with applicable requirements of ASTM C12.
3. Place circular pipe having elliptical reinforcement with minor axis of the reinforcement in a vertical position.
4. Prevent dirt from getting into pipe joints.
5. Remove pipe that is cracked, checked, spalled, or damaged from the work.
6. Clean interior of pipe of cement, dirt, and extraneous matter as the work progresses.

C. Pipe Joints:

1. Pipe joints shall be made secure and watertight.
2. Employ appropriate equipment to draw the sections of the pipe tightly together.
3. Joints of bell-and-spigot pipe and tongue-and-groove pipe shall be filled with cement mortar so as to make a strong and watertight joint. Finish joints smooth on inside of pipe with cement mortar.
4. Inside joint recesses of pipe shall be buttered with cement mortar prior to closure of joint. After closure is made, the joint shall be pointed inside the pipe and excess mortar removed by means of an inflated swab or squeegee.
5. Join PVC pipe in accordance with ASTM D2855.
6. Gasket joints for plastic pipe shall be in accordance with ASTM F477.

D. Backfilling:

1. Piping shall not be covered with backfill material, until inspected, tested, and approved in accordance with the Contractor's Management System.
2. After making up pipe joints, fill space between pipe and sides of trench with bedding sand or pea gravel half way up the pipe. Both sides shall be filled for full width of trench at same time and carefully compacted so as to hold the pipe in its proper position.
3. After pipe has been installed, inspected, and approved, place and compact backfill as specified in Section 33 05 28, Trenching and Backfilling for Utilities.

E. Concrete Encasement:

1. If pipe is indicated to be entirely or partly embedded in concrete, support and brace pipe in a manner that will prevent movement or displacement of pipe during testing and during placement and consolidation of concrete.
2. Place concrete as specified in Section 03 30 00, Cast-in-Place Concrete, being careful to consolidate concrete under and around pipe without displacing pipe.

3. Provide minimum Class 3000 concrete as specified in Section 03 05 15, Portland Cement Concrete.

F. Drainage Structures:

1. Unless otherwise indicated, installation specifications for drainage structures shall conform to section 33 05 16, Utility Structures, as applicable, and applicable manufacturer's standards.

3.2 CONCRETE

A. Provide and place concrete reinforcement and concrete as indicated and in accordance with Section 03 20 00, Concrete Reinforcing, and Section 03 30 00, Cast-in-Place Concrete. Provide headwalls and ditch closures with "smooth form finish" and ditch lining with "floated finish" in accordance with Section 03 35 00, Concrete Finishing.

END OF SECTION

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SECTION 33 46 00

SUBDRAINAGE

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Pipe and Fittings.

B. Drainage Material.

C. Installation of Pipe

D. Composite Underdrains

E. Installation of Permeable Drainage Layer

1.2 RELATED SECTIONS

A. Structure excavation and backfill are specified in Section 31 05 00, Common Work Results for Earthwork.

B. Trenching and backfilling for pipelines are specified in Section 33 05 28, Trenching and Backfilling for Utilities.

C. Site drainage and surface run-off collection system are specified in Section 33 40 00, Storm Drainage Utilities.

1.3 REFERENCE STANDARDS

A. ASTM International (ASTM):

1. ASTM C14 Specification for Nonreinforced Concrete Sewer, Storm Drain, and Culvert Pipe
2. ASTM C76 Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
3. ASTM C425 Specification for Compression Joints for Vitrified Clay Pipe and Fittings
4. ASTM C443 Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets
5. ASTM C444 Specification for Perforated Concrete Pipe
6. ASTM C654 Specification for Porous Concrete Pipe
7. ASTM C700 Specification for Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated
8. ASTM D1593 Specification for Nonrigid Vinyl Chloride Plastic Film and Sheeting
9. ASTM D2564 Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems
10. ASTM D2665 Specification for Poly (Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings
11. ASTM D2729 Specification for Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings

12. ASTM D3212 Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.
13. ASTM F758 Specification for Smooth Wall Poly (Vinyl Chloride) (PVC) Plastic Underdrain Systems for Highway, Airport, and Similar Drainage

B. State of California, Department of Transportation (Caltrans), Standard Specifications:

1. Section 29 Treated Permeable Bases
2. Section 88 Geosynthetics

C. American Association of State Highway and Transportation Officials (AASHTO):

1. AASHTO M252 Standard Specification for Corrugated Polyethylene Drainage Pipe, 75mm to 250mm (3” to 10”) Diameter.

1.4 SUBMITTALS

A. Shop Drawings: Submit detailed drawings that indicate subsurface drainage in plan and section, including relationship to other systems, interfaces, connections, alignment, grade, bedding, drainage and filter aggregates, and other pertinent data.

B. Product Data: Submit manufacturers' product data for pipe, pipe connection materials, permeable drainage liner for foundation walls and retaining walls, filter fabric (geotextiles), and impermeable sheet liner.

PART 2 - PRODUCTS

2.1 PIPE AND FITTINGS

A. Pipe Connection Requirements: Ends of pipe shall be bell-and-spigot, grooved, shiplapped, or secured with couplings, collars, or other connection fittings to assure continuous alignment of pipe.

B. Clay Pipe:

1. Pipe: ASTM C700, extra strength, perforated.
2. Joints and Gaskets: ASTM C425, ASTM D3212.

C. Concrete Pipe:

1. Plain Pipe: ASTM C14, Class 3.
2. Reinforced Pipe: ASTM C76, Class III, Class IV, and Class V
3. Perforated Pipe: ASTM C444, Type I perforations, and conforming to ASTM C14, Class 3.
4. Porous Pipe: ASTM C654.
5. Joints and Gaskets: ASTM C443.

D. Plastic Pipe:

1. PVC Pipe, Perforated: ASTM F758. Holes for all pipe sizes shall be 3/8-inch size. Perforated 4-inch diameter pipe may be ASTM D2729 or ASTM F758
2. PVC Pipe, Solid Wall: ASTM D2665, ASTM D2729, or ASTM F758, as applicable.
3. Cement: ASTM D2564.

2.2 DRAINAGE MATERIALS

A. Drainage and Filter Aggregates: Aggregate drainage and filter material (permeable material) for filling trenches under, around, and over underdrains, behind foundation and retaining walls, and for pervious blankets shall consist of clean, coarse sand and gravel or crushed stone, conforming to the following grading requirements:

Sieve Size	Percentage Passing Sieve
1 inch	100
3/4 inch	70-100
3/8 inch	40-100
No. 4	25-40
No. 8	0-33
No. 200	0-3

B. Asphalt Treated Permeable Material: Provide asphalt treated permeable base conforming to Caltrans Standard Specifications, Section 29.

C. Filter Fabric: Geotextile engineering fabric conforming to the Caltrans Standard Specifications, Section 88, Geosynthetics, Class A.

D. Preformed Permeable Drainage Liner: Prefabricated composite plastic drainage panels designed to provide hydrostatic relief for concrete foundation walls and retaining walls as indicated. Panels shall be a button-pattern or other raised dimple feature which forms a drain core with flow channels at least 3/8 inch in thickness or clear depth, with filter fabric bonded to the raised pattern to prevent soil from entering the core channels and blocking the flow of water. Furnish drainage liner complete with installation accessories.

1. Drainage Matting: Hydrostatic-relief drainage liner may be a composite drainage matting, consisting of a nylon or polypropylene core geomatrix of open, three-dimensional design, with a filter fabric bonded to the core to prevent soil from entering the core and blocking the flow of water. Minimum thickness or clear depth shall be 1/2 inch. Furnish drainage matting complete with installation accessories.

E. Impermeable Sheet Liner: Flexible membrane sheeting, polyvinyl chloride conforming to ASTM D1593, minimum 10 mils thick.

1. Adhesive: Synthetic rubber base cement, manufactured for use with polyvinyl chloride or synthetic rubber membrane material for cold application.
2. Tape: Tape for sealing of laps and joints shall be a pressure-sensitive neoprene or vinyl-chloride rubber adhesive tape as recommended by the manufacturer of the sheet liner material or a heavy-duty cloth masking tape, minimum 3 inches wide.

PART 3 - EXECUTION

3.1 INSTALLATION OF PIPE

A. Excavate trenches for underdrain pipe as indicated. When not indicated, excavate to a width equal to the outside diameter of the pipe plus 12 inches and to a depth of 4 inches minimum below the

grade established for the invert of the pipe. Coordinate with Section 31 05 00, Common Work Results for Earthwork, and Section 33 05 28, Trenching and Backfilling for Utilities, as applicable.

B. Lay impermeable sheet liner over prepared and compacted sub grade where indicated. Lap edges not less than 4 inches and ends not less than 6 inches, with all laps sealed continuously with adhesive and tape. Repair punctures and tears in liner sheets that occur during subsequent construction operations.

C. Lay filter fabric with sufficient width to encapsulate the drain aggregates with 6 inches of overlap after the placement of the aggregates. Provide 6 inches of overlap at ends. Temporarily secure the edges of the filter fabric at the top of the trench until the pipe and the drain aggregates have been placed.

D. Lay pipe to line and grade indicated. If pipe is of the bell-and-spigot type, lay bells in crosscuts cut in trench. Lay pipe with bell end uphill.

E. Fill space below the pipe invert with a layer of drainage aggregate as indicated, upon which the pipe shall be laid with perforations down. Sections shall be joined with sleeve couplings furnished by the pipe manufacturer or other appropriate method as determined by the pipe-ends configuration and approved in accordance with the Contractor's Quality Management Plan. Employ appropriate equipment to draw pipe sections together.

F. Rocks, bricks, broken concrete or asphalt shall not be used to give intermediate support to pipes. Large stones or other hard objects shall not be left in contact with the pipes.

G. Keep interior surfaces of pipes clean during placement. Block pipe ends with pipe caps or plugs to prevent any materials from entering the pipes.

H. Fill excavations for underdrains with drainage or filter aggregates as indicated. Place drainage aggregate and compact as required filling voids and preventing settlement, without damaging the underdrain pipe.

I. After pipe is laid and joined, obtain and document approval in accordance with the Contractor's Quality Management Plan before backfilling. Take up and re-lay or replace any pipe found to be out of alignment, settled or damaged.

3.2 COMPOSITE UNDERDRAINS

A. Construct composite underdrains as indicated. Surround perforated pipe with filter aggregates and envelope the composite underdrain with filter fabric as indicated. Provide solid-wall PVC pipe risers and cleanouts, including installation accessories, as indicated.

3.3 INSTALLATION OF PERMEABLE DRAINAGE LINER

A. Apply preformed permeable drainage liner or drainage matting to below-grade concrete walls as indicated. Apply panels in accordance with the manufacturer's instructions, with filter fabric side out.

B. Shingle each course, overlapping panels in the direction of water flow. Provide side laps in accordance with manufacturer's instructions.

C. Provide interface with subsurface drainage piping at footings where indicated. Follow manufacturer's instructions for correct interface installation.

END OF SECTION

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SECTION 34 11 27

BALLASTED TRACK

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Subballast.

B. Ballast.

C. Tie placement.

D. Rail installation.

E. Tamping.

F. Surfacing and aligning track.

1.2 REFERENCE STANDARDS

A. American Railway Engineering and Maintenance of Way Association (AREMA).

1. AREMA Manual.-Chapter 1-Roadway and Ballast

B. ASTM International (ASTM):

1.	ASTM C29/C29M	Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
2.	ASTM C88	Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
3.	ASTM C117	Test Method for Material Finer Than 75µm (No. 200) Sieve in Mineral Aggregates by Washing
4.	ASTM C127	Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
5.	ASTM C136	Test Method of Sieve Analysis of Fine and Coarse Aggregates
6.	ASTM C142	Test Method for Clay Lumps and Friable Particles in Aggregates
7.	ASTM C535	Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
8.	ASTM C702	Practice for Reducing Samples of Aggregate to Testing Size
9.	ASTM D75	Practices for Sampling Aggregates
10.	ASTM D6938	Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
11.	ASTM D4791	Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate

C. State of California, Department of Transportation (Caltrans), Standard Specifications:

1.	Section 17	Watering
2.	Section 26	Aggregate Bases

D. State of California, Department of Transportation (Caltrans), Standard Test Methods:

1. Calif. Test 201 Method of Soil and Aggregate Sample Preparation
2. Calif. Test 202 Method of Test for Sieve Analysis of Fine and Coarse Aggregates
3. Calif. Test 205 Method of Determining Percentage of Crushed Particles
4. Calif. Test 216 Method of Test for Relative Compaction of Untreated and Treated Soils and Aggregates
5. Calif. Test 217 Method of Test for Sand Equivalent
6. Calif. Test 229 Method of Test for Durability Index
7. Calif. Test 301 Method for Determining the Resistance "R" Value of Treated and Untreated Bases, Subbases, and Basement Soils by the Stabilometer

1.3 SUBMITTALS

A. Submit ballast shipping, handling, and placing plan and obtain the Contractor's engineer's approval of plan prior to shipment.

B. Trackbed Facilities Report: Submit a report documenting facilities in the trackbed.

C. Operating Instructions: Submit a copy of the manufacturer's operating instructions for the tamper machine.

D. Field Quality Control:

1. Submit report regarding the readiness of subgrade.
2. Submit test results of ballast gradation.
3. Submit subballast field quality control test results.

1.4 QUALITY ASSURANCE

A. Track subgrade (trackbed) is the top of subballast. The track subgrade may vary from the design elevations plus or minus one inch.

B. Except for the modifications, amplifications, deletions, and additions indicated herein, construct ballasted track in accordance with the requirements of the AREMA Manual.

C. Ballast shall be subject to inspection and testing at any time between quarry production and acceptance of track. Ballast that does not conform to these Specifications shall be rejected. Ballast operations shall be stopped until the defective material has been removed and replaced.

1.5 BALLAST TESTING AGENCY

A. Engage an independent testing agency to test the ballast at the quarry source to ensure that the classification, quality, and grading of the ballast at the time of shipment conforms to the specified requirements herein.

1.6 BALLAST SHIPPING AND HANDLING

A. Load only into rail cars (ballast cars) or hopper-type cars or trucks that are in good order, tight enough to prevent leakage and waste of material, and clean and free from rubbish and substances that may foul the ballast. If transported by trucks, the Contractor shall ensure that segregation, degradation, and contamination of ballast does not occur as a result of trucking and placing.

B. Handling

1. Handle prepared ballast at the producing plant, during shipment, and at the site so that it is kept clean and free from segregation. Ballast containing substances that may foul or damage the ballast will be rejected.
2. Do not make repeated passes of equipment over the same level in the stockpile area.
3. Prepare a plan for the proposed transporting from the source, handling, stockpiling, and final distribution and placing of ballast in track; including the location of all stockpiles and the identification, quantity, and condition of all equipment.

PART 2 - PRODUCTS

2.1 AUTHORITY-FURNISHED MATERIALS AND EQUIPMENT

A. Refer to the General Provisions for requirements regarding Authority-furnished materials and equipment, if applicable.

2.2 CONTRACTOR-FURNISHED MATERIALS AND EQUIPMENT

A. Furnish products, tools, materials, and equipment required to complete the Work.

2.3 SUBBALLAST MATERIAL

A. Subballast shall comply with the CHSTP Design Criteria and Caltrans Standard Specifications, Section 26, Aggregate Base requirements. Unless specified otherwise in the Construction Specifications, subballast shall be Class 2, 3/4-inch maximum grading, with the following additional requirements: Aggregate for subballast shall consist of crushed stone or gravel (reclaimed material will not be allowed), and shall consist of material of which at least 25 percent by weight shall be crushed particles as determined by California Test Method No. 205. Composition of subballast, in percentages by weight, shall conform to the grading shown in Table 1, determined in accordance with California Test Method No. 202.

Table 1 - Percentage Passing Sieves	
Sieve Sizes	**Maximum**
2-inch	0
1-1/2 inch	100
3/4-inch	90-100
No. 4	35-55
No. 30	10-30
No. 200	2-9

B. Subballast shall conform to the additional requirements shown in Table 2.

Table 2 - Additional Requirements		
Tests	**California Test Method No.**	**Requirements**
Resistance (R-Value)	301	78 min.
Sand Equivalent	217	22 min.
Durability Index	229	35 min.

C. At the time subballast is placed, it shall be free from organic matter and other deleterious substances.

2.4 BALLAST QUALITY REQUIREMENTS

A. Ballast shall be newly acquired from the supplier. Under no circumstances shall used ballast or ballast removed from existing track be used.

B. The amount of deleterious substances present in the prepared ballast shall not exceed the limits shown in Table 3, when performing the specified tests.

C. Particles having a width to thickness or length to width ratio greater than three shall not exceed five percent by weight of the total as determined by ASTM D4791. Round-rock, boulders, cobbles, and gravel are unacceptable ballast material.

D. The percentage of wear, when tested in the Los Angeles abrasion machine in accordance with ASTM C535, shall not exceed the percentages shown in Table 4.

E. The soundness of the prepared ballast shall be such that, when tested in the sodium sulphate soundness test in accordance with ASTM C88, the weighted average loss shall not exceed five percent after five cycles of the test.

F. Water absorption shall not exceed one percent when tested in accordance with ASTM C127.

G. Determine ballast weight per cubic foot in accordance with ASTM C29.

H. Ballast samples shall be obtained in accordance with ASTM D75. Test samples shall be reduced from field samples to testing size in accordance with ASTM C702.

Table 3 - Deleterious Substances		
Test For	**Percent By Weight**	**Test Method**
Material Finer than No. 200 Sieve	1	ASTM C117
Clay Lumps and Friable Particles	0.5	ASTM C142

Table 4 - Percentage Of Wear	
TYPE	**Percent**
Granite	35
Traprock	25
Quartzite	30

2.5 BALLAST GRADING REQUIREMENTS

A. Ballast (AREMA Size 4A) shall fall within the gradation requirements as shown in Table 5.

B. Determine the grading of the ballast in accordance with ASTM C136.

C. Ballast samples shall be obtained in accordance with ASTM D75. Test samples shall be reduced from field samples to testing size in accordance with ASTM C702.

Table 5 - Ballast Gradation	
Size of Square Sieve Opening	**Percent Passing By Weight**
2-1/2 inches	100
2-inches	90 to 100
1-1/2 inches	60 to 90
1-inch	10 to 35
3/4 inch	0 to 10
3/8 inch	0 to 3

2.6 SOURCE QUALITY CONTROL

A. Subballast material shall be sampled and tested in accordance with the California Test Methods specified herein, to determine compliance with specified requirements. Samples shall be taken from material as delivered to the site, and shall be prepared in accordance with California Test Method No. 201.

B. Contractor shall establish that the ballast quality, grading, and washing conform to the requirements specified herein at the time of shipment and shall ensure that the ballast conforms to the requirements specified herein when installed in trackwork.

C. Tests of ballast at the quarry source conducted by the independent testing agency shall included the following:

1. A test sample not less than 150 pounds shall be taken from a quarry test run of prepared ballast in accordance with the requirements of ASTM D75.
2. Perform the tests and inspections in accordance with Articles entitled “Ballast Quality Requirements” and “Ballast Grading Requirements” herein on the ballast samples.

D. Contracting Officer's Acceptance

1. Obtain Contracting Officer’s acceptance of ballast material prior to commencing delivery of the ballast to the site.
2. If, during ballast installation, the source of ballast changes, perform tests at the new production site in accordance with these Specifications. The ballast shall have the same classification, quality, and grading as the former ballast used. Delivery to the site shall not commence until the Contracting Officer has accepted the new ballast source.

PART 3 - EXECUTION

3.1 INSPECTION

A. Inspect and obtain the Contractor’s engineer’s approval of the prepared subgrade or subbase before proceeding with the subballast course.

B. The subgrade or subbase to receive subballast, immediately prior to spreading, shall conform to the compaction and elevation tolerances indicated for the material involved and shall be free of standing water and loose or extraneous material.

C. Prior to commencement of trackwork construction, determine the condition of the trackbed for all track types as to line, grade, and cross section, and compaction.

1. Subgrade settlement discovered at this time shall only be corrected by repairing the subgrade as specified herein.
2. Subballast shall be placed and compacted in accordance with the requirements specified herein.
3. Inspect and obtain the Contractor’s engineer’s approval of the prepared subgrade prior to the placement of ballast or other construction on the subgrade. Document the readiness of the subgrade in a report and submit report.

3.2 SUBBALLAST INSTALLATION

A. Apply subballast course over the prepared subgrade or subbase and compacted in accordance with Section 26 of the Caltrans Standard Specifications.

B. Subballast course shall be minimum uniform thickness after compaction of dimensions indicated. Where not indicated, compacted thickness shall be 6 inches.

C. All compaction expressed in percentages in this Section refers to the maximum dry density of the material as determined by California Test Method No. 216.

D. Delivery aggregate for subballast as uniform mixture of fine and coarse aggregate and spread in layers without segregation.

E. Subballast material shall be free of pockets of large and fine material. Segregated materials shall be remixed until uniform.

F. Subballast material shall be moisture-conditioned to near optimum moisture content in accordance with the applicable requirements of Section 17 of the Caltrans Standard Specifications.

G. Subballast 6 inches and less in thickness may be spread and compacted in one layer. For thickness greater than 6 inches, spread and compact subballast in two or more layers of uniform thickness not greater than 6 inches each.

H. Relative compaction of each layer of compacted subballast material shall be not less than 95 percent as determined by California Test Method No. 216.

I. Thickness of finished subballast course shall not vary more than one inch from the indicated thickness at any point. Subballast that does not conform to this requirement shall be reshaped or reworked, watered, and re-compacted to achieve compliance with specified requirements.

3.3 DOCUMENTATION AND PROTECTION OF FACILITIES IN TRACKBED

A. Survey and document the condition of facilities in the trackbed, including buried conduits in the track bed, conduit stub-ups, precast concrete trenches, sub drains and filter beds, cleanouts, ballast screens, and manholes. Incorporate the information in a report and submit the report prior to starting construction work and the operation of heavy equipment and vehicles on the trackbed.

B. Protect facilities in, under, or on the trackbed during track construction. Repair damage to the facilities caused by the Contractor's operations, and which was not a pre-existing condition as indicated in the Contractor's survey report.

3.4 PRELIMINARY BALLAST LAYER

A. Preparation: Correct all rutting and other damage to the subgrade prior to placing ballast.

B. Installation: A layer of ballast 6 to 8 inches deep shall be placed on the prepared subgrade or subballast for all main tracks, ready for compacting without further shaping. The ballast shall be compacted with not less than three passes of a vibratory roller of gross weight not less than 5,000 pounds, a drum not less than 58 inches wide and not less than 42 inches in diameter. The vibration frequency shall be between 1,100 and 2,000 vibrations per minute and shall impart a dynamic impact of not less than 9 tons. Avoid damage to existing facilities including sub-drains, stub-ups, conduits, and other structures.

C. Ballast Deck Bridges: Install a preliminary ballast layer on main track ballast deck bridges directly over the waterproofing protection boards, taking care not to damage the protection boards, the perforated deck drains, and any drainage existing facility on deck.

D. Ballast Finish: The top of the preliminary ballast layer shall be a level, flat plane, uniformly compacted prior to cross tie distribution.

3.5 CROSS TIE DISTRIBUTION

A. Position all ties with a jig in final location and normal to the centerline of track.

B. Position all ties within plus or minus one inch of required spacing, without accumulation.

C. Placing Ties

1. Place ties so the bottom of each tie will bear fully on initial layer of ballast.

3.6 RAIL INSTALLATION

A. Lay, join, and anchor CWR and jointed rail as specified herein.

3.7 TAMPER-LINER MACHINE

A. Utilize a production type tamper-liner capable of lifting, lining, and surfacing track and turnouts within the specified track tolerances and with the specified ballast. The machine shall be capable of external control of both line and grade. The machine shall be capable of external control of alignment utilizing a laser guidance system.

B. Each lift of ballast shall be thoroughly tamped, with a squeeze-type vibrating tamping machine, from a point 18 inches inside each rail on both sides of the tie to the end of the ties. The ballast shall be packed tight under and around the tie for the length specified. Tamping will not be permitted at the center of the tie between the above stated limits. Both ends of the tie shall be tamped simultaneously, and tamping inside and outside of the rail shall be performed at the same time.

C. Lift both rails together as uniformly as possible.

D. Operate tamper machine in accordance with the machine manufacturer's printed instructions. Submit a copy of the instructions to the Contracting Officer.

E. Do not operate the machine on tangent tracks unless the laser guidance system is utilized.

F. Tamper operation shall not damage ties. Replace ties damaged in any fashion by tamping of ballast. Patching or other repairs of ties will not be accepted.

3.8 PRELIMINARY SURFACING AND ALIGNING

A. General

1. Surfacing and/or aligning of the track shall not be performed when the rail temperature is higher than 100 degrees F.
2. Track surfacing and aligning shall be performed by methods which will prevent bending of the rail, straining of the rail joints, and damage to the ties or rail fastening assemblies.
3. All switch and switch machine rods shall be removed prior to tamping. The rods shall be replaced and the switch readjusted, as required herein, when tamping is completed.

B. Control and check the alignment of the track on the preliminary ballast with the necessary alignment and grade stakes.

C. Ballast:

1. Handle, transport, and place ballast to avoid segregation and generation of fines.
2. Place and maintain sufficient ballast in the cribs and shoulders to anchor the cross ties and prevent movement or buckling of the track due to temperature changes or equipment operation.

D. Lifting:

1. Track shall be lifted so that it will be necessary to give it a finishing lift of not less than one inch nor more than 2 inches to bring it to final grade. Alignment shall be maintained during the lifting operation.
2. Ties that have been pulled loose shall be replaced to proper position, and shall have a bearing against the rail, and shall be secured to the rail.
3. The amount of each lift, including that required for superelevation, shall not exceed 4 inches nor endanger the horizontal or vertical stability of the track.

3.9 FINAL SURFACING AND ALIGNING

A. A finishing lift and alignment shall be made to bring tracks to the true line and grade within the specified tolerances after completion of the preliminary surfacing and aligning.

3.10 BALLAST REGULATION

A. After final surfacing and aligning is completed, ballast shall be dressed as indicated. The portion of the subgrade outside of the ballast shall be trimmed an even surface sloped for drainage.

3.11 BALLAST CONSOLIDATION

A. Compact ballast with rail mounted equipment specifically designed to dynamically stabilize the track structure through the rail.

B. Dynamic track stabilizer capable of applying stabilizing forces into the track structure at a continuous speed of 1/2 mph. The equipment shall have an operational measuring system that provides for accurate measurement and control of stabilization.

C. The ballast shall be stabilized after each pass of the tamping machine.

3.12 MANUAL TAMPING

A. No manual tamping shall be performed.

3.13 SPACING AT TIE ENDS

A. Conduit stub-ups, manholes, buried vaults, cableways, foundations, walls, obstructions or other trackway construction shall be at least 12 inches outside of a line created by connecting adjacent tie ends.

3.14 FIELD QUALITY CONTROL

A. Contractor Testing: Sample ballast at the time of deposit on the trackbed, and perform a minimum of one gradation test and one test on material finer than No. 200 sieve for every 1,000 cubic yards of ballast delivered to the jobsite to ensure uniformity and conformance with the requirements specified herein. Submit a report of the test results. .

B. Replace in-place ballast not meeting the requirements specified herein.

C. Subballast Field Quality Control:

1. Test the relative compaction of each layer of compacted subballast in accordance with California Test Method No. 216.
2. Perform tests in accordance with ASTM D6938 to determine compliance with specified requirements for density and compaction of subballast and to determine moisture content of the installed subballast.

END OF SECTION